ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CVIII.—No. 2814.] *LONDON: FRIDAY, DECEMBER 5, 1919.* [*Registered at the General Post Office as a Newspaper.*] PRICE...9d. BY INLAND POST ... 11d.

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See Full Page Advt., page 93, Nov. 14.

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See Advertisement page 57. 3409

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See Full Page Advertisement, Nov. 14.

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See half-page Advertisement page 98, Nov. 28.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
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The National Foremen's ASSOCIATION OF THE ENGINEERING AND ALLIED TRADES.

(Registered under the Trade Union Act.)

An Association specially formed to look after the Interests of Foremen on their Supervisory Capacity. A 830

All communications to— H. W. RMID, General Secretary. Head Offices— 81, High Holborn London, W.C. 1.

IN THE MATTER OF J. W. BROOKE & CO., LTD., and IN THE MATTER OF THE COMPANIES' (CONSOLIDATION) ACT, 1908.

Notice is Hereby Given

that a Petition was on the 22nd day of October, 1919, presented to His Majesty's High Court of Justice by the above-named Company to confirm an alteration of the said Company's objects proposed to be effected by a Special Resolution of the Company unanimously passed at an Extraordinary General Meeting of the said Company held on the 30th day of July, 1919, and subsequently unanimously confirmed at an Extraordinary General Meeting of the said Company held on the 16th day of August, 1919, and which resolution runs as follows:—

RESOLUTION.

"That the provisions of Clause 3 of the Memorandum of Association of the Company with respect to the objects of the Company be altered by inserting immediately after Sub-Clause (d) of that clause the Sub-Clauses following that is to say:—

"(d.1.)—To carry on business as builders and repairers of ships, trawlers, tugs, lighters, barges, motor boats and other vessels of every description and of their engines, machinery, tackle and equipment, and to purchase, hire, charter, or otherwise acquire, sell, let out on hire or charter or otherwise deal with or dispose of any such ships or vessels as aforesaid or any share or shares therein.

"(d.2.)—To carry on business as ship owners and shippers, tug and barge owners, lightermen, stevedores, carriers by land and water, forwarding agents, wharfingers, shipping agents, ship brokers, salvers, dockowners and warehousemen.

"(d.3.)—To purchase, take on lease or otherwise acquire, build, construct and maintain any docks, wharves, slips, piers, plant, machinery and other works and conveniences for the building or repair of ships and other vessels.

"(d.4.)—To carry on business as owners of trawlers, smacks and other fishing boats, deep sea fishers, fishers, fish salesmen, ice manufacturers and cold storage proprietors."

And Notice is further given that the said Petition is directed to be heard before the HONBLE. MR. JUSTICE ASTBURY on FRIDAY the 19th day of DECEMBER, 1919, and any person interested in the said Company, whether as Creditor or otherwise, desirous to oppose the making of an Order for the confirmation of the said alterations under the above Act should appear at the time of hearing by himself or his Counsel for the purpose, and a copy of the said Petition will be furnished to any such person requiring the same by the Company's Solicitors, Messrs. BLYTH & HORNOR, of 11, Upper King Street, in the City and County of Norwich, or by their London Agents, Messrs. TARRY, SHERLOCK & KING, of 17 Serjeants' Inn, Fleet Street, in the City of London, on payment of the regulated charge for the same.

Dated the 24th day of November, 1919.

TARRY, SHERLOCK & KING,
17, Serjeants' Inn, Fleet Street,
London, E.C. 4.

Agents for
BLYTH & HORNOR,
11, Upper King Street,
Norwich,
Solicitors for the Company. B 933

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—A Practical Engineer, A.M.I.C.E., &c. (recently demobilised), has now resumed coaching for above by CORRESPONDENCE, after 11 years' highly successful pre-war experience. Separate subjects may be taken. Excellent testimonials. Fees moderate.—C 90, Offices of ENGINEERING.

Marconi's Wireless Telegraph COMPANY, LIMITED.

MARCONI HOUSE,
STRAND, LONDON, W.C. 2.

3rd December, 1919.

Dear Sir (or Madam),

On the 13th ultimo at an Extraordinary General Meeting of the Company a Resolution was passed authorising the increase of the Company's capital by £1,500,000. The *Times* report of the proceedings of this meeting was duly forwarded to you.

On the 28th ultimo the Confirmatory Meeting was held and a copy of the *Times* report of the proceedings of that Meeting is enclosed herewith.

At these Meetings the Chairman informed you of the important and extensive developments of the Company's business and the necessity for the substantial increase of the Company's capital in order to provide for the commitments already entered into and to be ready to carry out the offer, if and when called upon to do so, which the Company has made to the Government to construct and organise a thorough and efficient Wireless Telegraph Service between all distant parts of the Empire and the Mother Country.

In these circumstances and for the reason which has already been given at the Extraordinary General Meeting on 13th November, it was regarded as inexpedient to distribute a cash bonus to the Shareholders, but a promise was made that this should be compensated for by the terms of the issue of the new capital.

The Directors have pleasure in informing you that in fulfilment of this promise they have decided to issue the whole of the increased capital to shareholders only at £3 per share premium. This will entitle every shareholder, whether he holds Preference or Ordinary shares, to secure one new share at the price of £3 for every share he may hold on the 4th December, 1919, when the register will be closed.

Letters of allotment and renunciation will be posted to both classes of shareholders and due provision will be made for the holders of Share Warrants upon fulfilment of the necessary formalities. The new shares will rank for dividends declared in respect of the period commencing 1st January, 1920, but in all other respects will rank *pari passu* with the existing 1,250,000 Ordinary shares of £1 each.

The transfer books will be closed from Thursday, 4th December, to Tuesday, 9th December, inclusive, for the preparation of allotment letters, which will be posted to the shareholders on or about the 8th instant.

It will be remembered that the Profit and Loss Account for the year ending 31st December, 1918, showed a net profit of £597,933 9s. 0d., which together with the amount brought forward left the sum of £974,606 14s. 3d. to the credit of Profit and Loss Account. After payment of dividends amounting to 25 per cent. for the year on the Ordinary shares and 22 per cent. upon the Preference shares and transferring £150,000 to General Reserve Account (making a total to the credit of General Reserve of £1,250,000), a balance of £463,786 14s. 3d. was carried forward to the current year's account.

With the considerable additional capital which this issue will provide, and having regard to the immense development of Wireless Telegraphic and Telephonic business throughout the world, the earning powers of the Company should be greatly enhanced. The Directors are confident that the profits of the current year will justify them in maintaining the rate of dividend, and there is every reason to hope that the increase in the capital of the Company should at least produce a proportionate increase of profits in future years.

I am, yours faithfully, C 129

H. W. CORBY,
Secretary.

TENDERS.

COUNTY BOROUGH OF SALFORD.

GAS DEPARTMENT.

The Gas Committee Invite

Tenders for the Supply of

TWO NEW LANCASHIRE BOILERS, each 30 ft. by 7 ft. 6 in., and for the purchase and removal of two Old Lancashire Boilers, each 30 ft. by 7 ft. 6 in. Specification and full particulars may be obtained on application to the Gas Engineer, Gas Offices, Bloom Street, Salford.

L. C. EVANS,
Town Clerk.
C 69

INDIA OFFICE, WHITEHALL, 26th November, 1919.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL is prepared to receive

Tenders from such

Persons as may be willing to Supply VACUUM BRAKE GEAR, consisting of:—
Rubber Hose Pipes, Joint Rings, Rolling Rings and Washers.
Cylinders.
Cast-iron Stuffing Boxes.
Cast-iron Couplings.
Vacuum Gauges.
Piston Rods, &c.

The Conditions of Contract may be obtained on application to the Director-General of Stores, India Office, Whitehall, S.W. 1, and Tenders are to be delivered at that Office by Two o'clock p.m., on Friday, the 19th December, 1919, after which time no Tender will be received.

G. H. COLLIER,
Director-General of Stores. C 20

G. R.

The Admiralty have for Disposal H.M. PADDLE MINESWEEPER "CROXTON," particulars of which are as follows:—

Builders—
Ayrshire Dockyard Co., Ltd.
Hull—
Steel. Two complete Steel Decks.
Dimensions—
235 ft. B.P. by 29·1 ft. M.B. by 9·2 ft Mld. depth to lower deck.
Extreme breadth over paddle boxes 58 ft.
Gross tonnage 737·4.
Engines—Inclined Compound.
Boilers—Two Cylindrical Howden's draught.
W.P. 125 lbs. per sq. in.
Speed—15 knots.

Tender forms with permission to inspect may be obtained from the DIRECTOR OF CONTRACTS, Branch 8, Room 80, West Block, Admiralty, London, S.W. 1.

Tenders will be received up to 12 o'clock noon on Monday, 29th December, 1919. C 44

CLYDE NAVIGATION.

TO ENGINEERS.

ELECTRICALLY DRIVEN PUMPS.

The Trustees of the Clyde Navigation invite

Tenders for Electrically-

DRIVEN DE-WATERING PUMPS, for Nos. 1, 2 and 3 Graving Docks, Govan, Glasgow.

Drawings and specifications may be seen at the Office of Messrs. WALTER BRIDGES & CO., Consulting Engineers, 3, Salters' Hall Court, Cannon Street, London, E.C. 4, and at this Office, and copies thereof, together with Form of Tender, will be furnished on deposit of £2 2s., which will be refunded on receipt of a bona fide Tender.

Sealed Tenders, marked "Tender for Pumps," to be lodged with the undersigned not later than Tuesday, 30th December, 1919.

The Trustees may not accept the lowest or any Tender.

T. R. MACKENZIE,
General Manager and Secretary.
16, Robertson Street,
Glasgow.
28th November, 1919. C 25

GLAMORGAN AND CARMARTHENSHIRE COUNTY COUNCILS.

PROPOSED NEW ROAD BRIDGE AT LOUGHOR

TO BUILDERS AND CONTRACTORS.

The Joint Committee of the above County Councils Invite

Tenders for the Provision,

ERECTION, and COMPLETION of a REINFORCED CONCRETE BRIDGE (Hennebique System), to carry the Swansea and Llanelly Main Road over the River Loughor at Loughor, in substitution for the present Bridge.

Copies of the Drawings and Specification can be seen and Bill of Quantities obtained, at the Offices of the Glamorgan County Surveyor, County Hall, Cathays Park, Cardiff, and at Messrs. L. G. Mouchel and Partners' office, 36-38, Victoria Street, Westminster, London, S.W. 1, on and after Saturday, 22nd instant.

Contractors will be required to pay their workmen the recognised rates of wages, and to observe the recognised hours of labour, and must produce evidence of being insured against liability for accidents to workmen.

Sealed Tenders (containing the names and addresses of two substantial sureties or a satisfactory Guarantee Society in lieu thereof), marked on the outside "Tender for Loughor Bridge," addressed to the "Chairman of the Joint Committee," are to be delivered at my office not later than 6th December, 1919.

The Joint Committee does not bind itself to accept the lowest or any of the Tenders that may be received.

By direction of the Joint Committee.

T. MANSEL FRANKLEN,
Clerk of the Glamorgan County Council.
Glamorgan County Hall,
Cardiff.
18th November, 1919. B 785

The GOVERNORS of the SOUTH-WESTERN POLYTECHNIC INSTITUTE, Chelsea, S.W. 3, Invite

Offers for the Purchase of a

COMPOUND TANDEM HORIZONTAL DROP VALVE STEAM ENGINE, by Easton and Bessemer, Taunton, 100 HP., Cylinders 9 in. by 15 in. with 24 in. stroke, complete with surface condenser, throttle and expansion governors, speed changing device for speeds between 40–120 revs. Suitable for an educational institution. The Governors do not bind themselves to accept the highest or any Offer. C 107

TYNE IMPROVEMENT COMMISSION.

DREDGING PLANT.

The Tyne Improvement Commissioners are prepared to receive

Tenders for the Construction

and DELIVERY in the Tyne of the undermentioned:—

One Non-propelled Gear-driven Centre-ladder Barge-loading BUCKET DREDGER.
Two Steam HOPPER BARGES, each with hopper capacity of about 800 tons.
One STEEL BARGE, fitted with Steam Crane and Grab.

Copies of the Form of Tender and General Specification may be obtained from this office on payment of a deposit of five guineas for the Specifications, &c., of the Dredger and the Hopper Barges respectively, and one guinea for the Specification, &c., of the Steel Barge. The deposit will be returned on receipt of a bona-fide Tender.

Tenderers are requested to submit with their Tenders detail specifications and drawings of the vessel or vessels for which they are tendering.

Tenders, in sealed envelopes endorsed "Tender for Dredging Plant," to be addressed to the undersigned and delivered to him not later than Noon on the 12th January, 1920.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order,
J. McD. MANSON,
General Manager and Secretary.
Tyne Improvement Commission,
Newcastle-upon-Tyne.
5th December, 1919. C 136

APPOINTMENTS OPEN.

A Large Firm of Engineers

in the Midlands have an OPENING for a YOUTH of good education as premium pupil, the course to include both works and drawing office.—Address, 4359, Offices of ENGINEERING.

CITY OF BRADFORD EDUCATION COMMITTEE.

BRADFORD TECHNICAL COLLEGE.

Applications are Invited for

the position of WORKSHOP SUPERINTENDENT in the Engineering Department. Candidates must have had a good general education, technical training, and considerable practical experience in accurate engineering work.

Further information may be obtained on application to the PRINCIPAL.

By Order.
H 915

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The Water Committee of the

Liverpool Corporation REQUIRE the services of a temporary CIVIL ENGINEERING DRAUGHTSMAN with experience in Waterworks design.

The appointment will be of a temporary character at a salary of £300 per annum, with war bonus, which at present is 30/- per week.

Ex-service man preferred.

Applications, with particulars of training and experience, to be sent to the WATER ENGINEER, 55, Dale Street, Liverpool, not later than Friday, 12th December, endorsed "Civil Engineering Draughtsman." C 52

Applications are Requested

for the following APPOINTMENTS in INDIA:—

(1) ENGINEER-SALESMAN, having engineering training, and if possible some Sales Experience for the Sales Department of Firm manufacturing railway material.
(2) ENGINEER-DRAUGHTSMAN for designing and detailing light Railway Wagons, track work and Structural Material.
(3) OFFICE-MANAGER, having sound experience in Book-keeping, Costing, and general routine work of an engineering manufacturing firm.

Applicants should be well educated, single, preferably not over 30. Engagement will be for a term of three years, with progressive salaries.—Address, "R.B.D.," Box 2054, LEATHWAIT & SIMMONS, 9, Birchin Lane, E.C. 3. B 898

COUNTY BOROUGH OF WEST HAM.

MUNICIPAL TECHNICAL INSTITUTE, Romford Road, Stratford, E. 15.

Applications are Invited for

the following APPOINTMENTS:—

TEACHERS of Machine Construction and Drawing, on Wednesday, Thursday and Friday Evenings. Salary 15s. per evening.

Applications, with particulars of qualifications and copies of testimonials, should be sent to the PRINCIPAL, Municipal Technical Institute, Romford Road, E. 15, not later than 15th December, 1919.

GEORGE E. HILLBARY,
Town Clerk.

Education Department,
95, The Grove,
Stratford, E. 15,
26th November, 1919. C 5

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ROADS AND TRANSPORT CONGRESS AND EXHIBITION.

(*Concluded from page* 708.)

THE County Councils Association Road and Transport Congress reassembled on Monday, the 24th, at 2.30 p.m., when Mr. H. T. Wakelam took the chair and opened the proceedings by calling upon Mr. F. Wood, M.Inst.C.E., Blackpool, to introduce his paper, entitled "The Relative Advantages of Single and Double Coat Road Surfacing Work Carried out in Bitumen (as distinct from tar compounds)." This paper we print in abridged form elsewhere in this issue. It points out that good secondary roads are just as important as main roads, and that first cost is only one point to consider. It suggests that loans for this class of work should bear a direct relation to the actual life and describes types of construction used by the author. In introducing the subject the author said that he calculated that in 1914 only about 1,000 motor-buses were running on country routes on macadam. Yet they were blamed for all the damage the country roads suffered. If 1,000 did so much harm what would happen when the 30,000 or so 'bus chassis which the Government had to dispose of came on to the roads? Motor char-a-bancs were paying well and charging passengers 1*d.* per mile. Railways were charging 1½*d.* and the Government had to subsidise them to the extent of about 50,000,000*l.* yearly. He thought that money might go to the roads with better results. Roads were a national asset, and when they were troubled, as they were now, with high cost of materials he thought the Government ought to acquire control over such necessaries.

Mr. A. J. Lyddon, North Riding, Yorkshire, said that on the question of costs he would like more information than was given in the paper. Mr. Wakelam had given them a figure of 21*s.* per yard for his system; Mr. Dryland had described a cheaper method; then they had Mr. Drummond's system. The author gave 10*s.* per yard for laying. He, the speaker, thought that low; he would like to know what the life was on such a road with medium traffic. The whole question came down to one of costs. If with a system costing 10*s.* per yard the life was only about 10 years, or 1*s.* per yard per year, that did not show much advantage over tar-macadam. Col. Crompton had questioned the speaker's figure of 12*l.* per ton for bitumen. Mr. Wakelam had even told them it cost him 15*l.*; as a result the cost of bituminous preparation was high. Some cheaper binder, he thought, would be welcomed by all of them.

Col. R. E. B. Crompton stated that two-coat work had obvious advantages. It allowed the use of cheaper material for the bottom. Cost was the main question. He did not think that even yet the Ministry realised the supreme importance of roads, but the recent railway strike had done much to open people's eyes to the point. For traffic up to distances of 50 miles or so, the roads had the advantage over the railways, and a lot of traffic in this country was of this class. After circularising the country, he had found that the average cost of material had gone up 33 per cent. since pre-war days, but the cost of labour, including the inefficiency of the labour, had gone up two and a third times. Machinery and cheaper materials must be found to help them out. Scotch engineers had introduced simple machinery for spreading and had achieved very marked success with it. Their costs for road surfacing were about half what they had been with the old method.

The present price of bitumen was, of course, ridiculous, and could not be maintained. It was due to want of freight. He thought it would come down to 5*l.* or 6*l.* per ton. Otherwise it would be necessary to consider coal tar products, treating them so as to make them last better. It was found that in the South of England these lost their oil, and the surface ultimately became brittle and had to be renewed every three years. On the other hand, the climate of the North of England seemed to be better suited to them. Mr. Brodie, at Liverpool, had used them successfully right up to the surface. He thought pitch might be successfully bitumenised in the near future. There were two or three promising systems. The paper dealt with two-coat systems. Some engineers had cheapened the upper coat with a pitch and bitumen mixture. If they took bitumen at 9*l.* and used one-twelfth by weight in the top coat, 1 ton of bitumen with 11 tons of aggregate would give say 130*l.* for 12 tons of spreading material. If this were spread at say 20 yards to the ton, a figure only about two-thirds that of the authors would be reached. It would be still lower if synthetic bitumen were adopted. The author had rightly laid stress upon the consolidation of the under coat. It was essential that the top coat should be thoroughly supported.

Mr. A. Dryland, Surrey C.C., said generally he believed in two-coat work. He had a lot of single coat work which had proved successful, but in other cases it had not been a success. In some instances thin coats laid on macadam have disappeared. Defects had sometimes arisen from the poor quality of the undercoat on which it was laid. Some had been destroyed by traction engine traffic. The expenditure had been justified by the life they had given. However, he had not laid any for five or six years now; such roads were not suitable for heavy traffic, but might do for light traffic roads. He did not advocate taking up and re-using the top surface unless there was ample foundation below. In single surface work repairs did not give a good bond with the base. Two-coat work had the advantage there. You could chip off the top and put in a patch which adhered firmly to the bottom. If one coat were used, it was necessary to keep to ½-in. aggregate, and then it became comparatively expensive. Did the author's costs include repayment of principal and interest. In classifying his roads the author had said that if a road cost more than 4*d.* per super yard per annum, bitumen structure was substituted. The speaker would have put that figure at 5*d.* or 6*d.* If they could get freights down the price of bitumen would come down.

Mr. Birch, Westrumite Company, said the single coat system was introduced here in 1912 just prior to the war. Till then bitumen had been used hot. It could, however, be used pure in the cold state. He believed in the application of a single coat of liquid bitumen on a properly formed base. It sealed the road surface and prevented moisture from working through.

Mr. L. Roseveare put two or three questions to the author, and asked what was the thickness of the coat used by him. Mr. Horton, Derbyshire, who followed, also asked whether the author's figures for cost included capital cost and charges for cleaning. He thought all charges ought to be included. The last paragraph of the paper did not include the cost of the aggregate itself. Most of them would have to provide fresh material. The purchase cost of that, and the haulage would make a very heavy addition to the figure. He thought tar macadam roads would be used for most of the country roads, but they could not be left to themselves with just the annual tarring.

Miss Verney, Stratford-on-Avon, R.D.C., referred to the slipperiness of modern roads, and related a number of cases which had come directly to her knowledge of recent accidents due to slippery roads. Some consideration ought to be given to the horse, as there was a great deal of horse traffic even in towns, while it predominated in the country. Horse users paid rates and their lives should be protected in some way.

Sir R. Usher, Midlothian, supported the last speaker. So far no practical suggestion had been made at the conference dealing with the subject. He thought that there was difficulty in combining macadam and bituminous roads. Water from one got under the other. Perhaps a curb might be put in between the two surfaces. He would like to hear the views of people on roads for moderate traffic. They all went to the Government when they wanted money, and they were taxed up to the hilt already. He thought the people who were forcing them to alter the roads should be made to pay a large part of the cost. When the railways were made they paid for building the lines. In Scotland they sprayed their tar macadam roads every year when under heavy traffic, and every two years in the case of lighter traffic.

Mr. O. E. Winter, Borough Engineer, Hampstead, said he had overcome slipperiness on tar-dressed, roads by using ¾-in. crushed flint. The dressing was run over afterwards by a steam-roller. This gave an excellent foothold, in fact, a better one on steep grades than macadam. He had used it on grades of 1 in 8, and had very few complaints of slipping. It was certainly a little costly to use liberally, but in the eight or ten years he had used it, had given very good results. In the case of bituminous-surfaced roads it was possible to lay grades of 1 in 30 without serious slipping. Then they used sanding after frost. For medium traffic roads he thought a two-coat road of 1½-in. tarred slag and 1¼-in of top bituminous coat gave good results.

Mr. W. A. Farnham, Sidcup, did not agree with the use of crushed flint. With regard to the high price of bitumen, it was important to keep the proportion used in the aggregate down to a minimum. Larger quantities than this would also result in corrugation. On many roads creep and ruts were noticeable, proving that too much bitumen had been used. The ideal was a minimum of bitumen and a maximum of wearing material. They ought to work in that direction.

Mr. Conlon, Willesden, said he spoke as a layman who had to come before the ratepayers and give explanations. He believed in bituminous roads, and preferred them to wood, especially as regards maintenance. With regard to slipperiness, he thought attention should be turned to the horse-shoe.

Mr. Aspell, who had taken the chair when Mr. Wakelam had had to leave to attend another meeting, said that if a road were to be made costly to the traffic it was not economical, and again if a road required an amount of repairs which interfered with traffic that also was unsound.

The author, in reply, said that while tar macadam cost 1*s.* per year over a life of five years, bitumen cost 10*s.* for a life of about 25 years. The cost should be divided over the actual life; not on the loan life. Fifteen years was a safe life—many of his had lasted 25. His pre-war cost of 6*d.* was for foundations and new work, not cleansing. If loans were proportioned to life the cost of the new system would come down. The cost of bitumen per yard was now 2*s.* 6*d.*; prior to the war it was 1*s.* Using old material they, therefore, had this extra 1*s.* 6*d.*, together with the additional cost of labour. Machinery was required to bring this down. He thought bituminous roads less slippery than tar-painted roads. He had used old material because he had had to excavate in any case on account of levels. In some cases he had taken out 15 in. and had put in 3 in. of base and 1 in. of topping, with the result that the road was standing better than it had done before. As soon as a bituminous road was cold you could pass a 10-ton lorry over it.

After a vote of thanks to the author and chairman, the meeting adjourned.

EXTRAORDINARY TRAFFIC DAMAGES.

On the conference re-assembling on Tuesday, the 25th, the chair was taken by Sir H. E. Clare, and the paper considered was one by Mr. S. G. Turner, the subject being "The conditions under which the heavier types of vehicles may use the roads, with special reference to their liability for extraordinary traffic damages." This paper was a discussion of the existing law and of decisions in this country regarding extraordinary traffic. It concluded with the following general propositions: (1) That as a matter of policy roads should be improved so as to enable them safely to carry the new traffic, and this traffic should not be regulated or restricted merely to fit it for existing roads; (2) That every form of traffic should be permitted to use the roads without being subjected to special taxation; (3) That the present method of recovering expenses in respect of damage caused by extraordinary traffic should not be altered so as to revert to the prohibition of such traffic; (4) That any necessary departure from (1) and (2) to meet existing circumstances should be regarded as a temporary expedient only. The author, in introducing his paper, said the ideal to be aimed at was freedom of communication. Highways should be produced capable of bearing all traffic that would

come upon them provided makers would produce the best type of vehicle. The law recognised the principle of payment for damage by extraordinary traffic, but not the restriction of such traffic. Traffic which at one time might be extraordinary in time might cease to be so. It had been proposed that damage might preferably be assessed by an arbitrator rather than by a judge and jury. He thought vehicles should be made to pay for the damage they cause by way of licence. Possibly speedways would be constructed for fast traffic. As tolls were impossible, he thought the users of these would also have to have special licences in order to make them contribute towards costs.

Mr. Marks, Bedfordshire, said that what they had to consider was the fate of the existing roads in the immediate future. That depended upon the Ministry of Transport. He believed that Ministry would be responsible for the reconstruction of all first and second class roads to fit them for all traffic which might reasonably come upon them, and would contribute to maintenance. He preferred two expert arbitrators and a legal adviser instead of the assessment of damage by a jury. The omnibus companies conferred an inestimable benefit on country districts, and he did not see why they should be penalised when other users put heavy traffic on the roads for their own personal profit only. He knew of a case where a motor omnibus had carried 114 people though licensed to carry 36. Powers should be given to enable rural districts to deal with that sort of thing.

Mr. J. C. Haller, Nottingham, stated that in their districts they usually managed to get agreements beforehand with contractors who were putting heavy traffic on their roads. They might decide on 6*d*. per ton-mile for restoration, and if the cost did not work out to that the balance was remitted. In some cases the contractor might refuse to enter into an agreement, and if pressed for costs would threaten to go bankrupt. There should be a tribunal to settle the costs before the damage was done. He hoped all mechanically-propelled vehicles would be taxed. In the case of traction engines he thought there should be power to limit the roads used. Traction engines with show vans could traverse the whole of his county for 2*s*. 6*d*. He had had two cases lately of new roads being completely spoilt by such trains. In the case of damage due to hauling a 16-ton boiler from Gainsborough to Glasgow, they had had to recover damages from the contractor in the courts. The boiler was for the Admiralty, and, by getting into touch with that department, in the case of other loads for the Admiralty, they were not only given notice by the department, but the contractor was restricted by the Admiralty to follow routes which the speaker had advised.

The Right Hon. Henry Hobhouse said he thought the Select Committee over which he presided 20 years ago had done good in connection with the question of damage by extraordinary traffic. They were now asked to go further. Arbitration was not always satisfactory, and arbitrators, unlike judges, usually failed to lay down principles for future guidance. There should be a distinction between omnibus traffic put on the country roads to serve the district and omnibus tourist traffic which travelled for pleasure only at high speed and for long distances, doing great damage to the roads.

Mr. Hunter, Stirlingshire, had had a great deal of extraordinary traffic during the war. They had tried to put on an impost, but as the vehicles passed through the districts of several authorities it had been impracticable. Fortunately, the actual damage was small. They had been hard hit by the motor-'bus. Because one horse-drawn wagonette had run over a certain road carrying four passengers once a day they had had to spend between 3,000*l*. and 4,000*l*. to make that road fit to stand a regular motor-bus service.

Mr. J. Diggle thought traffic should be restricted till the roads were made fit for it. In his district they had numbers of 36-ft. roads which suffered badly in the rush of the railway strike. In these roads houses butted right into the road. They had no less than ten main bursts as a result of the heavy traffic on their roads during the strike.

The usual votes of thanks concluded the morning meeting.

Heavy Motor Vehicles and Road Maintenance.

The chair was taken at the afternoon meeting by Lord Montagu of Beaulieu. Three papers were to be considered under one title, viz:—"The Weight, Construction and Speed of Mechanically Propelled Vehicles in Relation to the Construction and Maintenance of Roads." The papers were respectively by Mr. A. E. Brookes, Mr. G. Hoare and Mr. W. D. Williamson. They are reproduced in abstract elsewhere in this issue. In introducing his paper, Mr. Brookes stated that the interests of the highway authority and manufacturer were really common. Motor vehicle owners should be willing to admit the principle of contributions to the upkeep of roads. Both manufacturers and users recognised the necessity for uniformly good roads. In most cases the present legal maximum axle load was often exceeded. He thought 9 tons might be permissible under restriction.

Mr. Williamson, following, said the better the roads the lighter the vehicles they could put on them. He thought a 9-ton axle load reasonable. For roads as they were at present a 4-ft. wheel with rubber tyres might be advisable, but it should not be necessary. They should be allowed to design on the assumption that they would use reasonably good roads. Mr. Brooke's figures were not convincing. He had not stated whether he considered the road he instanced as suitable for the traffic it had. If his road was costing 4*d*. per car mile for repairs that was more than the tyre rate for vehicles. He thought, therefore, the road could not have been suitable. Their roads would soon have broken down completely if the traffic required by the railway strike had continued.

Mr. Hoare said that the present regulations were framed 15 years ago, since when there had been a great advance. They should not consider reduction of weight. Now that a road programme was in hand they should provide for the future. For steam wagons a 9-ton axle load would suffice at present. The front axle should not be reduced to 3 tons, but left at 4, and the 1 ton added in the rear. Rubber tyres added to the weight.

Mr. G. H. Jacks, Herefordshire, said in the end it was a question of cost. If the surveyors had the money they would all provide roads suitable for any present or future traffic. Roads must be made to suit the traffic, but must also be made suitable for horse traffic. In counties such as his, horse traffic would continue for a long time. They had had several accidents lately. Mr. Brookes suggested separate roads. That he thought impossible. He could see no solution at present as motor traffic must, he thought be given precedence.

Mr. E. S. Sinnott, Gloucestershire, said they were in the unfortunate position as regards their roads in that during the five years of war they had not been able to make any progress with reconstruction, while overseas mechanical transport had in that time developed enormously. While the one had progressed therefore, the other had remained stationary, while if there had been no war both would have advanced simultaneously. At present they could not get the necessary material. He would like the use of heavy traction engines to be limited. He would like to see further development of the Bolton wheel. Regarding the suggestion of alternative roads, he had recently been engaged in three small improvements which had cost, taking land, fencing, culverts and the construction of the road itself, with small pieces of retaining walls, no less than £15,000 per mile. That made large alternative road schemes out of the question. He would not like to see lorries moving at 20 m.p.h. on his roads—you could not outrage other users of the roads who paid rates. They must be given time to carry out improvements.

Mr. E. Willis, Chiswick, said his experience of petrol and steam vehicles pointed to their economical employment on the longer distances. In the war his steam wagons had worked on the longer routes, and costs had been below 3*d*. per ton mile. When a lot of time was wasted in stopping and picking up it was more economical to use a horse service. When loaded, he found the weight on his front axle to decrease. Design, therefore, was not yet perfect. He exceeded the back axle load, although the total was within the limit. The load should be equalised rather more, even at the risk of loss of power. He had two vehicles with platforms 4 ft. above the ground, built with dropped axles and chain driven. They were very good, and the men liked them for loading. Instead of "unladen" weight, what was wanted was the weight as it was ordinarily upon the road.

Mr. Aveling, Birmingham, said economical transport was the first consideration. Regulations had made the present commercial vehicle a success. The early German 'buses had been regulated off our roads by Sir E. Henry, while our makers had developed a type which could not be beaten in the world. Rubber tyres must come because they were more economical. "Unladen" weight was not needed nowadays. In roads they had to get down to specifying their stresses and then building roads to suit.

Mr. Lewin, Yorkshire Commercial Motor Company, said vehicles fitted with rubber tyres weighed anything from 3 to 3½ cwts. less than corresponding steel tyred vehicles, thus increasing the possible load. He did not wish the front axle load reduced below 4 tons. It was well known that tyre makers had now withdrawn their guarantees. That was because makers had not kept to the prescribed axle weights. Often they had 1 ton extra or an axle, and the tyres had crushed out. With rubber tyres the stresses set up in the vehicle were less, and the vehicle could be designed lighter.

Major A. T. Davis said manufacturers should adhere to regulations as regards weight. They had weighed traction engines and found that many of them came out three or more tons over the scheduled weight stated on the engine plate.

Mr. Brookes, in reply, said the road referred to in his paper was a trunk road in excellent condition originally. His suggestion for 9 tons axle load was merely legalising a practice which at present was followed illegally. That weight might be legalised, and a very heavy penalty enforced for exceeding it.

Mr. Hoare said he thought the Bolton wheel suitable for setts, but not for macadam. His view was that if they insisted on rubber tyres they should allow for the extra weight his experience showed to be necessary.

Mr. Williamson said "unladen" weight was not wanted. If British vehicles had been made the best by Sir E. Henry's regulations, then they wanted another Sir E. Henry to bring the roads by means of regulations to a condition second to none.

Lord Montague of Beaulieu agreed that the unladen weight served no purpose except perhaps with regard to loading. The road makers wanted the loaded axle load only.

After votes of thanks the conference adjourned.

Road Finance.

The 1919 congress met for the consideration of its last paper at 11 a.m. on Wednesday, the 26th. Brigadier-General Sir H. P. Maybury, K.C.M.G., C.B., Director-General of Roads, occupying the chair. The paper considered was by Mr. W. Rees Jeffreys, the subject being "Future Traffic Developments." This paper we print in somewhat curtailed form elsewhere in this issue. As its consideration was spread over the morning and afternoon sessions, it was determined to take for the morning discussion the subject of Finance and Classification, forming Section II of the paper.

The author introducing this subject said as regards roads, finance underlay all the practical problems. If that were tackled first we would be able to make progress. They had excellent engineers, and he had no doubts whatever on the engineering side of the question, but only on the financial side. There were four questions, viz.: (1) how much ought we to spend; (2) how much could we afford; (3) who was to find that money; and (4) who was to spend it. In 1913-14 they were spending 18,000,000*l*. in England and Wales, on roads. This included charges, improvements and cleansing. That divided over the population meant that the roads were costing less than 10*s*. per head, or taking men, women and children, less than ½*d*. per diem. Was there any other service for which they got

better value? Roads were everything to one's existence from birth to death. If only the country would give the engineers 1*d.* per diem, or 1*l.* a year for some years they would provide the finest roads in the world. Our roads were more economically administered than any other service, and better value was obtained for money spent on them here than in any other country. Money so spent was productive. He thought the roads probably required the expenditure of about 180,000,000*l.* That might be spread over five or more years. That would not include money for new roads, road widenings, new bridges, &c. We might manage to spend 40,000,000*l.* a year, raised something after the following manner:—About 23,000,000*l.* might come from rates; about 6,000,000*l.* or 7,000,000*l.* from the users of vehicles, of which the heavy motor users would have to stand much larger taxation than at present; and the remaining 10,000,000*l.* could be met by loans. The roads should be administered by the local authorities in close co-operation with the Ministry of Transport. He thought it was unwise to press for too high a percentage grant for maintenance. His scheme B showed how much more beneficial was a lower percentage spread over more mileage. The point was large maintenance grants should not be made at the expense of general improvement.

Mr. H. P. Bouluois said the paper was a good exposition of the new act. The money spent on roads was a national asset; it was not lost. The author had shown how small an amount per head was needed. In London they would have starved in 48 hours in the strike had it not been for the roads. He always held that the roads should be free to all users. If they started taxing types of traffic there was no knowing where they would stop. He hoped the building up and maintenance of the roads would not be taken out of the hands of the local authorities. He might say on this point that lots of authorities paid their surveyors miserable salaries and could not expect to get the best work from them in consequence. Classification was difficult, and when considered should take into account the case of roads which were just beginning to develop traffic, or might be expected to do so shortly.

Mr. Aspell, Chairman Highways Committee, Lancashire, said many of them had for years been pleading for a reduction of the local burden. The author's figures gave no promise of that, and in view of the reduced value of the *l.* it would actually be greatly increased. If the author intended local taxation to raise 23,000,000*l.* for the roads he thought the Treasury contribution should relieve them of rather more. He had formerly suggested that the motor lorry user should pay £100 per annum per vehicle, but had been howled down. He did not suggest that figure now, but it was clear that the general attitude on this point had changed. When the cost of bringing up the roads to the new standard had been paid, special contributions by such users might cease and they might be put on the same footing as others. He thought 7,000,000*l.* per annum a reasonable figure for this transition period. In view of the limited period of this transition phase he did not think one-quarter of the sum should be raised by loans. He thought rates and taxes should raise all but the 7,000,000*l.* Administration should be left to local authorities under suitable guidance. The main highways, however, should not be left in the hands of the smaller local authorities, but should be managed by the technical staff of the county. He agreed with the author's B scheme, which would stimulate bringing up the roads to a high standard better than would large grants to a smaller mileage of Class I roads.

Mr. H. H. Copnall said that finance was the foundation of highway law reform. He agreed with the principle of the B scheme. What was meant by super-first roads, of which they had read so much lately? The Great North Road passed through about 70 authorities. Was it to become a super-road over its whole length. In some parts it carried a lot of traffic—in others very little. In Nottinghamshire it carried less than the road between Nottingham and Derby. Between Coventry and Birmingham the traffic was more than on the Holyhead Road in the Welsh Hills.

Sir H. Maybury said that no decision had been reached regarding super-first roads. They would be guided by local authorities. The proposal had been put forward by the Road Board in 1914. It was intended to take into account trunk roads connecting the large towns. For instance, on the Coventry-Birmingham road 97 per cent. of the traffic using the road originated in one or other of these two towns, neither of which contributed to the cost of the road.

Mr. J. L. Redfern, Gillingham, said an extra proportion of the road costs should be borne by the road users. The tramway and railway companies had to contribute. The smaller authorities found it very hard to meet demands made upon them and wanted greater assistance. Mr. Berryman, Somerset, was of the opinion that the smaller scale of grant for the larger proportion of mileage should be adopted. While in agreement with the undesirability of increasing loan charges, they were faced by the fact that many roads were not good enough as regards lay-out, &c., to justify bringing them up to a high standard. They needed improvement first in line and lay-out, and therefore some sacrifice of the general principle as regards loans would have to be made in such instances.

Mr. A. Dryland agreed with the previous speaker as regards loans for improvement of lay-out. Often roads were not in a physical condition to meet the traffic which might be expected to come on them. In connection with finance it was necessary to bear in mind the value of the *l.* The author's 40,000,000*l.* would not go much further than the 18,000,000*l.* the roads had cost in 1914. He thought the grant money should be spread over as large a mileage of main roads as possible. They should remember that a tax on commercial vehicles would fall ultimately on the community, as the vehicle users would take care to recoup themselves in the charge for work done. The value of property depended largely upon accessibility. It was therefore fair that some of the maintenance and development costs should fall on the property owners. The rest should fall on the users.

Mr. W. E. Bush said that in New Zealand the principle was already applied of making the large cities contribute to roads and bridges outside their areas, if it could be proved that they used them. In the U.S.A. the Federal authorities contributed to all roads on which the mail service ran. In 1919 the sum devoted to this had been $65,000,000. Road users should contribute to costs because it was to their interest to have good roads.

Mr. J. A. Brodie, Liverpool, said the cost of first class roads had gone up to three times what they were in 1914; for the lighter class of roads costs had doubled. So much work was behindhand that he thought that more than 40,000,000*l.* would be wanted. So long as they had to pay double or more for work not so well done, he thought those responsible for that arrangement should find much of the additional money. The money should be spent where there was, or was likely to be, traffic. His city had applied some time ago to Parliament to be allowed to contribute to roads outside their own boundaries; unfortunately these powers had not been granted. Such contributions did not greatly affect a large town provided they could get a guarantee that the work was well done. In these questions they had to take the wider aspect. Before the war he had been assured by competent authorities that motor vehicle users were prepared to contribute 20*l.* per vehicle per annum, if assured in return of good roads. He did not think that one class should be mulcted in charges escaped by others; all should contribute a just proportion.

Sir R. Usher agreed that it was now accepted that we might expect a considerable contribution from motor users. He was also glad to hear that municipalities were to be asked to contribute. As a horse user he had no objection to do so also, but the horse user was usually also a local ratepayer and would therefore be paying twice.

Mr. Farneham, Sidcup, preferred instead of Class 1, 2 and 3 roads, to classify them as national roads, country roads and local roads. The first, national roads, should be maintained by national funds by the county authorities. The country roads should be maintained by county taxation with, if advisable, Imperial grants. Local roads should be maintained by the rates.

In reply to the discussion on this section of his paper, Mr. Rees Jeffreys agreed that 40,000,000*l.* was not enough, but was a fair start. The salary of surveyors should be improved. He would like to see a minimum salary of £500, but would also like to reduce the number of small local authorities. If a local authority could not afford that salary for its surveyor, it was not competent to be a road authority at all, and such small bodies should hand over their repairs to the large bodies who were completely and properly staffed. The smaller might contract with the larger. They could not finance large improvements without loan accounts. They took the place of capital. It was cheaper than maintaining a road in unsuitable form. The Federal Road Act of the U.S.A. failed through the grants being distributed too widely. In that country there had been a wave of enthusiasm for good roads.

NEW ROADS.

In the afternoon, Sir H. Maybury opened the meeting by stating that if they introduced new services many roads would have to be widened. The railways were subsidised to the extent of 50,000,000*l.* to-day. If that were withdrawn, the rates would go up to the extent even of 50 per cent. That would bring more traffic on to the roads.

Mr. Rees Jeffreys, with reference to Section I of his papers (New Roads) said one new road that he had long advocated was now under construction, but there was no hope of building many like the new western approach to London. It was too costly. Such roads were, however, wanted in other places in the approaches to great cities. There was no means at present, without special legislation, of constructing new arterial roads passing through several authorities. The Town Planning Act should be strengthened so that such roads might be planned. Local authorities could, if in agreement, combine to carry out a joint scheme, of which arterial roads might form a part. In practice this did not work when the scale was that of the Western Avenue. Something would have to be done to get the required unity. As regards finance, part of this could be dealt with by an advancement of money to be recouped subsequently on the development of the adjoining property.

Mr. J. A. Brodie referred to what the author said about authorities working together. It would be a long time before cities and the adjoining authorities or even two Government authorities, would be able to work well together. However, he suggested that a judicious pressure might be exerted from headquarters either to coax a bit, or squeeze a bit. Liverpool had powers to acquire under its special Act, land to a depth of 40 ft. on either side of the centre line of a new road free, and additional land at estate value. Bye-pass roads were important. No first class roads should be arranged for in town planning which left less than 120 ft. between houses. They had earmarked this width in many cases for future schemes of development in Liverpool. It was a remarkable thing that the Road Board had built no roads. He thought a great opportunity had been lost. In Liverpool they had reconstructed and widened 20 miles of road during the life of the Road Board. He thought the powers of the Liverpool Act of 1908 might be applied to the whole country with good effect. They should not be alarmed at the prospect of having to deal with roads through towns. They would have to be widened whether they liked it or not. He had schemes for providing a width of 120 ft. driven admittedly along the cheapest lines, across his city to its centre. Birmingham had laid down a line 60 ft. on either side of the centre of its main approach roads. That might be done by other cities.

Mr. Aspell said he thought the paper had intended an immediate large expenditure on new roads. He thought that they should first concentrate on their present roads, with a view to the future. All the material that could be obtained during the next few years would be wanted for existing roads. These, if suitably improved and strengthened, could deal with traffic for many years to come. They had many arrears to make up. He pleaded

that Government help in the form of advice and grants, should be devoted to their present roads. If a modification of the Town Planning Act would help them to set aside land which might ultimately be useful for new roads he thought that about as far as they could expect to go at present. In his district they had heard very little about the need for new roads.

Mr. John Burns stated that if he had remained at the Local Government Board he would have introduced a short Bill on the Liverpool lines. The time had arrived, he thought, when, in nine-tenths of the cases, the local authorities should be given freedom to work out their own destiny. If the Liverpool Act, 1908, and the Town Planning Act and a Paving Act of 1817 were combined, they would have a short cut through most of their present difficulties. He had never liked the Road Board, and was against all centralised authority. The only function a central authority should have was to act as a clearing house for ideas and to carry out experiments for everybody. Let no central over-organised departmental administrator think that the English people would abandon the wise and proved system of local government which had stood them in such good stead these many years. A central authority should only have a small staff to collect data and dispose of grants, and it should interfere as little as possible with local authorities. He wanted to see local autonomy with wide independence of the citizen ratepayer and freedom from the over-lordship of bureaucracies run by supermen. They wanted variety of action in regard to roads because the materials available varied. Engineers should be given more freedom.

Sir H. Maybury interposed here to state that he hoped he would approach his war work with the one desire to help his old colleagues. He was heart and soul with the full maintenance of local government.

Mr. L. Roseveare, South Shields, described an instance of a road to a borough five miles distant, of 20 ft. width, along which castings 18 ft. wide were taken. This road could not be widened because it passed through a rural district between these two points. They had wanted 120 ft. width, and the rural council could not agree. In a town planning scheme they had got land given to them for a 120 ft. road and they would have developed new sites and so saved the cost almost entirely. There was no comparison between the new 120 foot road and the widening of the old. The new road would have been far cheaper, yet the rural council could not stand the cost of construction.

Mr. Dryland thought there were cases where a central authority was needed, as in early stages of arterial work. It was then difficult to get co-operation. Schemes such as those to avoid big towns also required some central authority to look after them.

Mr. Rees Jeffreys said the last two speakers brought up the real issue. Mr. Roseveare had cited the case of a bit of road in a rural district which should be dealt with as part of a larger scheme, but the rural council could not finance it owing to its small rate value. For this there were two solutions; (1) we should have to look to a central department to finance such schemes; or (2) regional authorities would have to be set up and the cost distributed. He was a local government man. If local government were inefficient, bureaucracy would increase. Local government should be made more efficient by giving the authorities more powers, and the means of making experiments.

The third section of the paper was then read but did not evoke discussion. It is reprinted abridged elsewhere, so need not be referred to here. After votes of thanks to the author and to General Sir H. Maybury the meeting terminated.

German Competition in Morocco.—We read in *The Board of Trade Journal*, that German firms in the hardware trade are displaying considerable activity in Morocco, and are offering very advantageous terms with a view to securing business. Price lists and requests for orders are being addressed to all the principal merchants, and a great point is being made of the advantage which the present low value of the mark confers upon foreign buyers of German goods. Three months' credit is being freely conceded, and unless British firms are prepared to do the same it may be very difficult for them to secure business.

MASS PRODUCTION AND INSPECTION.

Whenever articles are manufactured in bulk, by what are generally known as "mass-production" methods, some form of inspection is necessary. Whether the goods manufactured be pins or watches, simple or intricate, roughly made or highly-finished, inexpensive or costly, the quality must be controlled in some manner or other. The ultimate control of quality, whatever the standard decided upon, must be by inspection.

Where the parts manufactured are very simple, and where very wide manufacturing limits can be adopted, inspection is usually a very simple matter and need not necessarily be an independent function. For example, pins or tin-tacks must get some form of inspection, or viewing, before they are finally despatched from the factory. In such cases, however, the cost of inspection should be very small—often too small to be costed as a separate item. Indeed, inspection is not always recognised as such, but that it actually exists in some form or other in every case, there can be absolutely no doubt; otherwise a lack of uniformity in the product would eventually result. This would on the one hand increase manufacturing difficulties to an impossible degree, and on the other hand would most probably result in the loss of markets for the goods.

At the other end of the scale, where articles have to be highly finished or made very accurately to fine limits, or must be interchangeable with other parts, or are very intricate in themselves, or have to fulfil several or all of the above conditions, inspection becomes of distinct importance. In such cases it is easy to under-estimate the importance of the inspection function; but, where the success of the parts manufactured depends largely on the maintenance of a high and uniform standard of finish or accuracy, there is a real necessity for adequate and reliable inspection.

In high quality work made on "mass-production" lines, the only really satisfactory way is for the inspection to be a separate and independent function, with the necessary authority to decide definitely—subject to appeal to the Management—on all questions of quality. While recognising that high technical ability may be necessary for the design of both the article manufactured and the tools and equipment for manufacturing it, and that much mechanical skill of a high order may be necessary for the actual manufacturing, it is on the inspection that ultimate reputation depends. The inspector, therefore, is a person of some importance, though it is feared that he is looked upon sometimes as a necessary evil—like policemen and cats.

In the case of high-class work, the cost of inspection is inevitably high; and generally speaking, the higher the grade of work (of its type) the greater the proportional cost of inspection. The difference in cost between a first and second-rate article of the same kind is often largely made up of the increased cost of inspection; though this is not very obvious and is often overlooked by the works management, the sales staff, and finally the customer.

Inspection expenses are, admittedly, difficult to control. When the need for economy becomes especially urgent (though the need is always there, really), it is an almost irresistible temptation to start on the inspection department. Of course, it may easily happen that the cost of inspection could be reduced without decreasing its efficiency. To a greater or lesser degree, the same can be said of all departments in a works, for departments, like individuals, are seldom perfect. But perhaps in no other section of a factory is a drastic and ruthless sacrifice to economy more perilous, especially in cases where the product is of a high grade. Even slightly to impair the efficiency of the inspection department is to endanger the quality of the goods manufactured. When the quality falls, reputation is apt to fall with it, and demand tumbles down in its wake. When this happens it is seldom possible to get quite back again to the original position, however desperate the attempt. If the true cause of the trouble is not detected—and it most likely will not be detected—panic ensues; prices are cut; further "economies" are introduced to balance the reduced prices—and so the vicious circle is travelled again. And it should not be forgotten that a soiled reputation lives long after the facts change. The moral of all this need not be emphasised.

The position, therefore, regarding inspection of work produced by "mass-production" methods may be summarised as follows:—

1. Some degree of inspection is always essential.
2. The higher the standard of work produced, the greater is the need for inspection.
3. The cost of inspection is necessarily a greater proportion of the total cost in the case of high grade products, than in the case of lower grade goods of the same kind.
4. A reduction in inspection efficiency, however brought about, will almost certainly result in a deterioration of the quality of work produced, and will re-act unfavourably on the commercial prosperity of a business as a whole.

UNITED STATES PATROL BOATS OF "EAGLE" CLASS.

Although these vessels had no opportunity to display their value in the work for which they were intended—the hunting of German submarines—they are well worth study as embodying the ideas of American naval officers regarding the most promising methods whereby the submarine menace could be defeated. To naval architects the features of the design indicate the manner in which provision was made for rapid production in large numbers by a firm lacking skilled workmen and experienced foremen. To all shipbuilders the methods adopted by this firm are of interest as they show the constructive ideas of automobile engineers who had successfully manufactured a very different type of engineering product, and who desired to apply that experience to the quantity production of ships.

The military requirements of the design were an armament of two 4-in. guns, one 3-in. high-angle gun, one depth charge thrower of "Y" type and two sets of rails for about twelve depth charges, a speed of 18 knots, a radius of action of 3,500 nautical miles at 10 knots, and the most up-to-date listening equipment.

These requirements when worked out gave a vessel with the following particulars:—

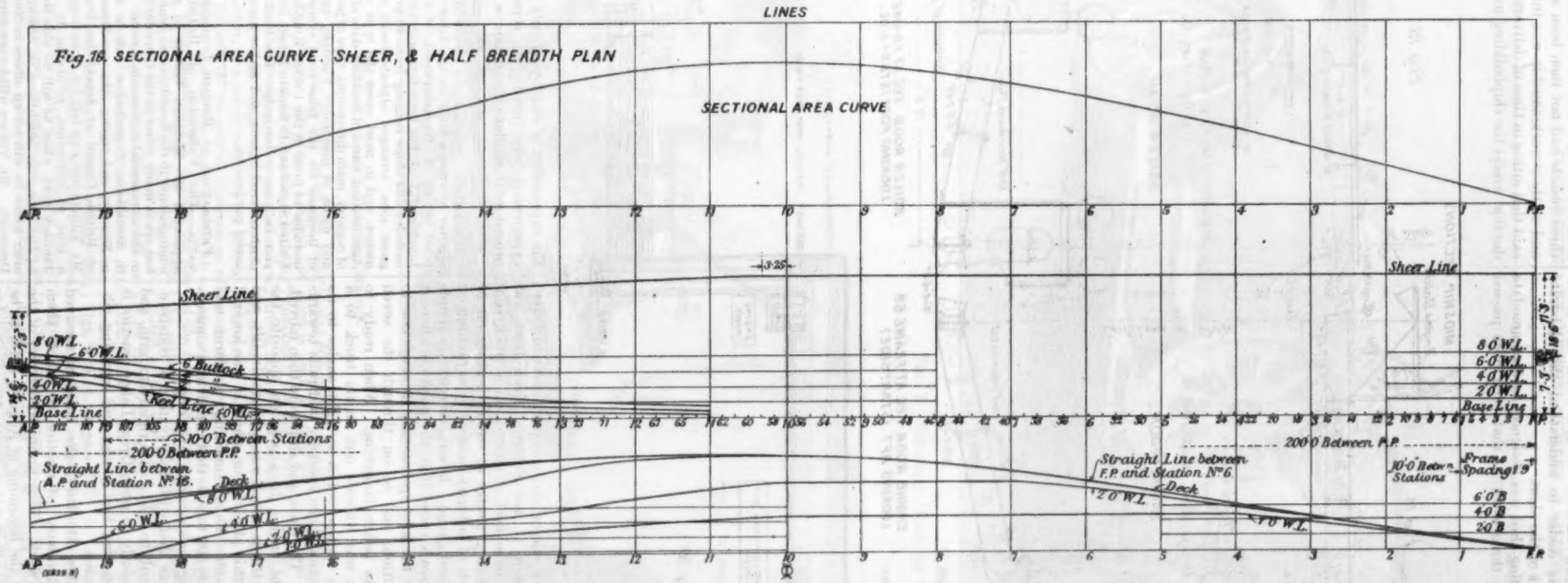
Length between perpendiculars ...	200 ft.
Breadth	25 ft. 6 in.
Draught	7 ft. 3 in.
Displacement...	500 tons.
Freeboard—	
Forward	11 ft. 3 in.
Amidships	11 ft. 3 in.
Aft	7 ft. 3 in.
S.H.P. of machinery...	2,000
Weight of hull and hull fittings ...	237 tons.
,, armament	40 tons.
,, machinery	82 tons
,, reserve feed water ...	10 tons.
,, fuel carried on load draught	60 tons.
,, equipment (*i.e.*, electric fittings including electric machinery, anchors and cables, rigging, &c.)	17 tons.
,, outfit (*i.e.*, boats and furniture) and stores ...	27 tons.
,, fuel for desired radius of action	90 tons.
,, fuel with tanks full ...	148 tons.

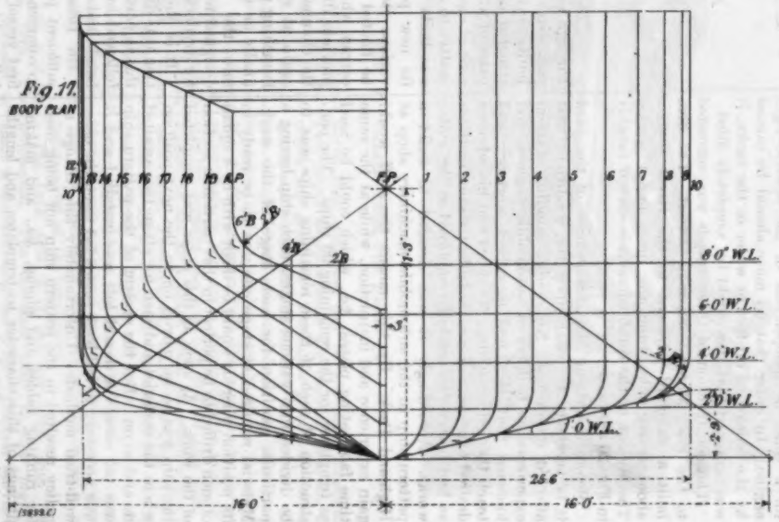
It was realised that, on account of their size, it would not be easy to ensure that these vessels would be steady gun platforms. As it was desirable, in order to simplify construction, to omit bilge keels, rolling experiments were carried out at the Model Basin, Washington, and it was found necessary to fit these keels. The metacentric height, however, was kept moderately low, viz., 1 ft. (allowing for free surface of oil and water) in the normal load condition, the corresponding range of stability being about 70 deg.

It will be seen from an examination of the sheer drawing on Plate XLIV that simplicity making for easy and rapid work was sought in every detail. The form was designed so that water lines and deck outlines were absolutely straight for a considerable length in the forward and after bodies, thus maintaining a constant bevel for the frame angles. The sections were given straight sides and the lower frame lines were kept straight while those of the fore body were given a constant rise. Complete frames could therefore be built up in simply constructed moulds which could be used for a large number of sections with very little alteration. The round of bilge was so confined that it could be included in one strake

UNITED STATES NAVY PATROL BOATS OF THE "EAGLE" CLASS.

(*For Description, see opposite Page.*)





Stations.	Half-Breadths (Moulded). Water Lines. 1 ft.	2 ft.	4 ft.	6 ft.	8 ft.	Deck.	Stations.	Heights (above Moulded Base). Buttock Lines. Keel Line.	2 ft.	4 ft.	5 ft.	Main Deck and Side.	Dead Rise.
F.P.	—	—	—	—	—	—	F.P.	—	—	—	—	18– 5–0	—
1	1– 3–7	1– 6–3	1– 6–3	1– 6–3	1– 6–3	1– 6–3	1	—	—	—	—	18– 6–0	0– 3–6
2	2– 7–6	3– 0–5	3– 0–5	3– 0–5	3– 0–5	3– 0–5	2	—	—	—	—	18– 6–0	0– 1–4
3	3– 9–7	4– 5–5	4– 7–0	4– 7–0	4– 7–0	4– 7–0	3	—	—	—	—	18– 6–0	0–11–4
4	4– 8–7	5– 9–7	6– 1–3	6– 1–3	6– 1–3	6– 1–3	4	—	—	—	—	18– 6–0	1– 3–6
5	4– 8–7	7– 2–0	7– 7–5	7– 7–5	7– 7–5	7– 7–5	5	—	—	—	—	18– 6–0	1– 7–6
6	4– 8–7	8– 4–5	9– 2–0	9– 2–0	9– 2–0	9– 2–0	6	—	—	—	—	18– 6–0	1–11–7
7	4– 8–7	9– 2–5	10– 6–3	10– 6–3	10– 6–3	10– 6–3	7	—	—	—	—	18– 6–0	2– 3–1
8	4– 8–7	9– 2–7	11– 7–6	11– 7–6	11– 7–6	11– 7–6	8	—	—	—	—	18– 6–0	2– 6–0
9	4– 8–7	9– 3–1	12– 4–4	12– 4–4	12– 4–4	12– 4–4	9	—	—	—	—	18– 6–0	2– 8–0
10	4– 8–7	9– 3–3	12– 8–0	12– 9–0	12– 9–0	12– 9–0	10	—	—	—	—	18– 6–0	2– 9–0
11	4– 2–5	8– 3–0	12– 8–3	12–10–1	12–10–1	12–10–1	11	—	0– 5–2	0– 9–7	1– 5–1	18– 2–5	3– 1–0
12	3– 7–1	7– 0–1	12– 3–3	12– 8–6	12– 8–6	12– 8–6	12	—	0– 6–0	0–11–4	1– 8–3	17– 9–7	3– 7–0
13	2–10–6	5– 7–2	11– 0–5	12– 4–3	12– 4–3	12– 4–3	13	—	0– 8–0	1– 3–3	2– 1–3	17– 6–0	4– 5–0
14	2– 3–5	4– 6–1	8– 8–7	11– 7–7	11– 9–7	11– 9–7	14	—	0–10–4	1– 8–4	2– 8–1	16–11–6	5– 4–3
15	1–10–2	3– 8–0	7– 0–6	10– 4–6	11– 1–0	11– 1–0	15	—	1– 1–0	2– 2–1	3– 4–7	16– 6–7	6– 3–0
16	1– 6–7	3– 0–0	5– 9–6	8– 8–6	10– 2–2	10– 3–0	16	—	1– 4–0	2– 7–5	4– 1–7	16– 2–0	7– 1–0
17	—	0–11–5	3–10–7	6–10–7	9– 2–1	9– 3–6	17	1– 5–3	2– 8–0	4– 0–3	5– 4–3	15– 9–0	7– 7–6
18	—	—	1– 9–1	4–10–5	7–11–2	8– 4–5	18	3– 0–3	4– 1–3	5– 4–7	6– 7–4	15– 4–0	8– 1–4
19	—	—	—	2– 8–3	6– 5–2	7– 5–3	19	4– 7–5	5– 6–5	6– 8–2	7– 8–0	14–15–7	8– 5–7
A.P.	—	—	—	—	4– 4–3	6– 6–1	A.P.	6– 2–7	7– 0–0	7– 9–7	8–10–7	14– 6–0	8–10–4

of plating, consequently no other bottom plating required bending. The deck beams had no round-up and the sheer was provided by two straight lines, hence deck erections could be built as square houses, brought to the ship complete and riveted down. No flare was given to the forward sections. Before deciding upon this simplification a model was towed through waves at the Model Basin under circumstances imitating those to be expected in practice, and it did not appear that the presence of flare would make the forecastle less wet than if the above-water entrance were kept fine. Capacity to manœuvre quickly was an essential feature, and to provide this a rudder of large area was arranged.

As it was known that the building of these boats would be entrusted to a firm with no experience whatever of shipbuilding, scantlings were fixed with a view to allowing a margin of strength to cover possible bad workmanship, rather than to reducing the hull weight to a minimum. The stresses accepted were 4·7 tons per square inch tensile and 3·9 tons per square inch compressive; these were calculated for the more severe condition, viz., hogging at a displacement of 600 tons when the bending moment was assumed to be 4,800 foot tons.

The midship section is given in Figs. 18 and 19, annexed It will be observed that the number of different sections and thicknesses of plating employed was kept to a minimum, and that angle smith's work was avoided as far as possible, even to the extent of omitting frames around the curved bilge strake.

The machinery consisted of two oil-fired boilers and a "Poole" turbine running at 4,250 r.p.m., driving a single screw at 475 r.p.m. On trials the required shaft horse-power was easily developed, and the speed of 18 knots obtained.

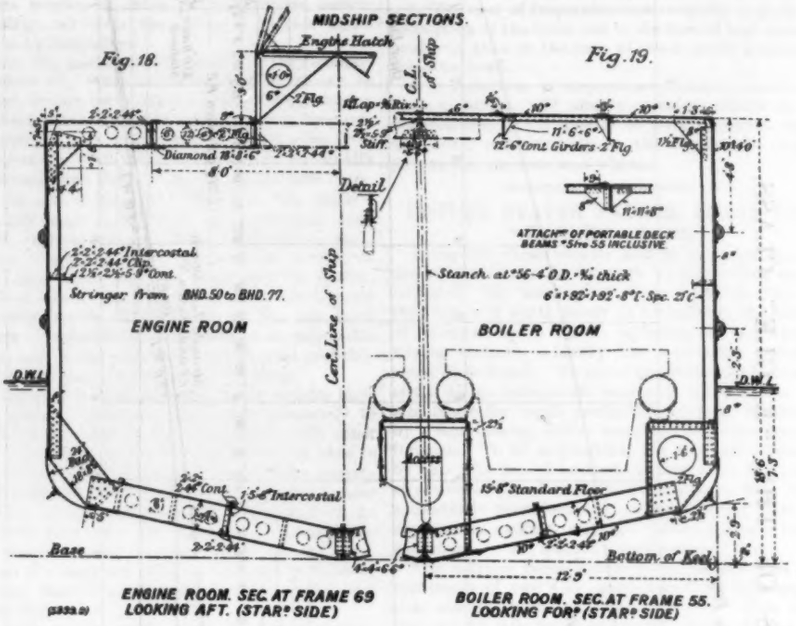
The general arrangements are shown in the views on Plate XLIV. A noteworthy feature is the high commanding position of the 4-in. guns. It can also be seen that the listening requirements involved special consideration. As the efficiency of the apparatus to be installed depended on the noiselessness of the main and auxiliary machinery steel wire hawsers were substituted for chain cables, storage batteries were fitted so that the ship could, for a time, be independent of the electric light engine. In order that no noise should be caused by the motion of oil fuel or water in the tanks, it was arranged that they could be completely filled.

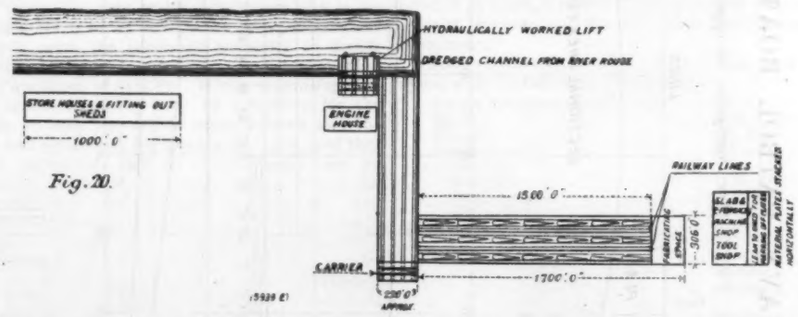
The construction of these vessels was entrusted to the Ford Motor Company, Detroit. The firm built a shipyard adjacent to the River Rouge, about seven miles from the main motor works. The lay-out of the establishment is shown roughly in Fig. 20 annexed

Before describing the arrangement of the yard it is necessary to touch upon the conditions that affected its design. No doubt, mindful of their experience as builders of automobile engines, and knowing that they had to collect workmen and teach them shipbuilding, Mr. Ford and his advisers desired to adopt, as far as possible, the same methods as had been so successfully employed at the motor works. Accordingly it was decided to build a pattern ship in the automobile machinery shop at Highland Park. By this means the staff would gain experience and instruction, while at the same time fabricating plates, &c., which could be used as templates for the remaining 99 ships. The construction of each of these remaining ships was to be divided into various stages, each ship having a particular position for each stage of the work. Material required at stage one was to be ready in its position where it would be dealt with by a squad of men drilled to be perfect in that particular section of the work. As soon as this stage was completed the ship was to be moved on to the next position where the material and men for stage two awaited it, and so on. But the system of the pattern ship was too slow. A mould loft was installed and it was necessary to fall back somewhat upon the older well-tried methods. Unfortunately this change of policy resulted in the pattern ship not being used for running cables and piping, &c., and making fittings of this character to templates and lengths worked out in this first vessel.

With these ideas as to the sytems of construction to be adopted, and the local condition that the ground level was about 12 ft. above the water level in the narrow channel dredged from the River Rouge, it is easier to understand the elaborate arrangement of the plant.

The building shed was designed to accommodate 21 ships in three rows, so that each boat passed





through seven stages and occupied seven different positions before it was floated. Each boat was built, on an even keel of course, on a truck constructed of heavy baulks of timber resting on 24 pairs of wheels of ordinary railway type running on rails of standard gauge. It was, therefore, a simple matter to move a vessel from the position where it was built by the men specialising in stage one to its new position, and so on through the seven various stages before launching. When ready to be floated it was wheeled out on its truck to a carrier which transported it at right angles to its previous direction down specially laid rails towards the channel. The truck and ship were then moved, again at right angles, to a position opposite the launching platform, which was a hydraulic lift, and finally on to this platform on which it was lowered into the water. This launching platform was designed to lift 500 tons so that it provided a means for drydocking the ships at a later stage.

It is obvious that with this system of construction it is difficult to hold a ship rigidly to form, and this is particularly so when Great Lakes practice is followed in spacing keel blocks and omitting ribbands and shores.

On December 31, 1917, the builders received sufficient preliminary information to enable them to commence work. They promised delivery of the first vessel at the beginning of August, 1918, to be followed by four during that month, 25 in September and the remainder before the first week in December, 1918. At the time the armistice was signed eight boats had been completed, of which three had been taken over by the United States Navy. These three vessels had not then been actively employed, and as their workmanship was inferior it cannot be said that either in time of delivery or quality of production would the shipbuilding methods adopted or the experiment of employing only unskilled and inexperienced men justify the repetition of similar procedure if similar circumstances ever arose.

Isherwood System of Ship Construction.—A register of vessels built on the Isherwood system, compiled by Mr. J. W. Isherwood, of 4, Lloyd's Avenue, London, E.C. 3, has been forwarded to us. The register includes 564 ships ranging from 40 gross tons to 11,150 gross tons, arranged alphabetically according to their names, and in most cases the type of vessel, tonnage, classification, name of builders, date of construction, port of registry, main dimensions, type of propelling machinery and name of machinery builders, are given. The list of licensees for the Isherwood system of construction includes 44 firms in the United Kingdom, 37 firms in the United States and 15 firms in Japan, Italy, Spain, Holland and Belgium collectively. The book is bound in blue cloth-covered boards, and makes a very interesting and useful publication.

Federation of British Industries and Scandinavia.—The Federation of British Industries has appointed Mr. Montagu Villiers to act as their trade commissioner in the Scandinavian countries. Mr. Villiers has spent many years in the Consular Service, and lately in the commercial diplomatic service. He is well known in Stockholm, Copenhagen and in commercial circles in Norway, and among other positions he held was that of British Consul at Stockholm from 1906 to 1913. Mr. Villiers has now left for Scandinavia, and will make a tour of inspection, returning to England early in January next, when he will be able to make a report as to the economic conditions in Scandinavian countries, after which he will set up offices in Norway, Sweden and Denmark. Mr. Villiers will be accompanied by Mr. John Pitcher, who has made a special study of transport and trade conditions in various countries.

15·9-H.P. FOUR-CYLINDER MOTOR CAR.

CONSTRUCTED BY MESSRS. HUMBER, LIMITED, ENGINEERS, COVENTRY.

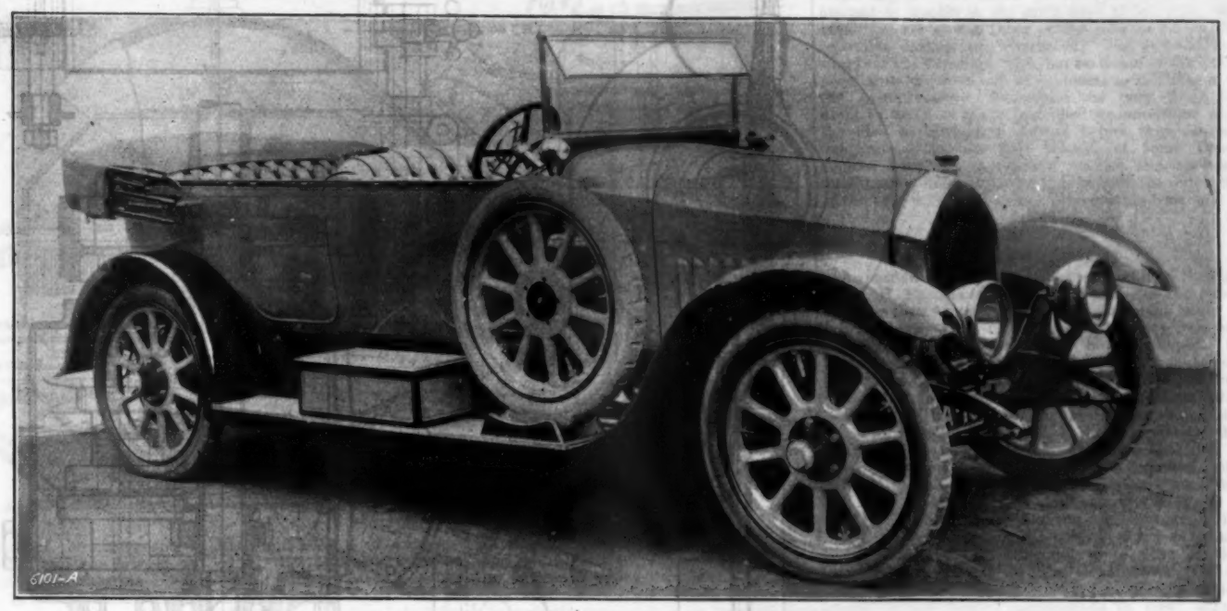


FIG. 1. GENERAL VIEW OF CAR.

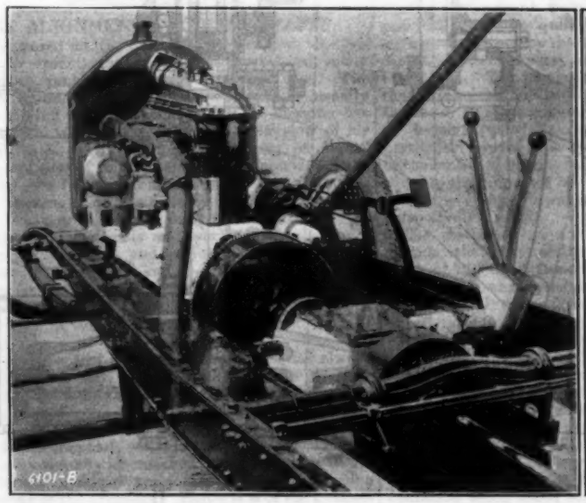


FIG. 2. FRONT END OF CHASSIS.

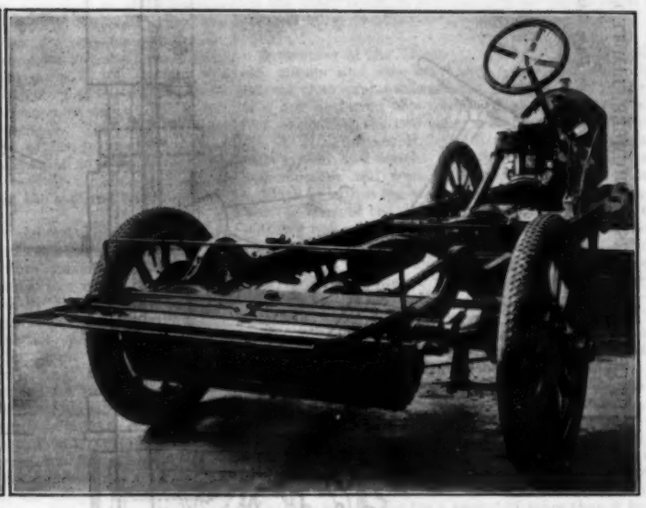


FIG. 3. CHASSIS FROM THE REAR.

THE new 1920 motor-car models which are being manufactured by Messrs. Humber, Limited, of Coventry, consist of one of 10 h.p., which is being fitted with a two-three-seater, a four-seater and a *coupé* body, and one of 15·9 h.p. which is built either as a five-seater tourer, or a saloon car. On the present page and pages 746 and 747 we publish illustrations of the 15·9-h.p. chassis, the car complete, fitted with a five-seater body being shown in Fig. 1. The car has a wheel base of 10 ft. 3½ in., with 4-ft. 9-in. track. The overall length is 14 ft. and the width 5 ft. 9 in. The chassis for either the tourer or saloon models are identical except that the former has 815-mm. by 105-mm. tyres, and the latter 820-mm. by 120-mm. tyres. In both cases detachable steel artillery-type wheels are fitted. The chassis, as will be seen from Figs. 4 to 6, on page 746, contains no striking novelty of arrangement and must be regarded rather as an example of modern, clean, good-class design than as aiming at anything very new.

The engine, an end view of which is given in Fig. 5, on page 746, has the four cylinders in monobloc, each being 80 mm. bore by 140 mm. stroke. Forced lubrication is used, a rotary pump delivering oil through the crankshaft to the various bearings. The pump is driven from the camshaft, and enclosed in the sump. Ignition is by high-tension magneto and a Smith's automatic carburetter is fitted. Autovac feed is used, the petrol tank, of a capacity of 13½ gallons, being slung from the underside of the rear members of the frame, as shown in Fig. 4. The petrol feed to the carburetter on the Autovac system is from a tank bolted to the dashboard under the bonnet. Cooling is by forced circulation from a centrifugal pump, the usual radiator fan being fitted, as shown in Fig. 5. Constructional details of the radiator are given in Figs. 9 to 14, on page 747. A C.A.V. electric lighting set dynamo and self-starter are incorporated with the engine.

The clutch, shown in Fig. 6, on page 746, is of the Humber enclosed leather-faced cone type. The withdrawing mechanism is completely enclosed in the front end of the gear-box. The arrangement is clearly shown in the figure. The mechanism is protected from dust and can be efficiently lubricated. Two fabric flexible joints are inserted between the clutch and gear-box. The latter gives four forward speeds and reverse with direct drive on top gear. The gate-change levers are carried on one side on an extension of the gear-box casing, as can be seen in Fig. 2. Transmission from the gear-box to the propeller shaft is through a fabric flexible joint. The member forming the gear-box end of this joint is formed to act as a brake drum on which a flexible band type, Ferodo-lined, brake operates. This is controlled by a foot pedal. Details of the operating gear are given in Figs. 7 and 8, on page 746, while the arrangement can also be seen in Fig. 2. The engine control levers are placed on top of the steering column. The foot accelerator works in conjunction with, but independent of, the hand lever.

The back axle is of the live type, with bevel differential. The universal joint on the propeller shaft is enclosed, and runs in oil. The rear wheels are fitted with large diameter, Ferodo-lined internal expanding brakes, operated by a hand lever fitted to

15·9-H.P. FOUR-CYLINDER MOTOR CAR.

CONSTRUCTED BY MESSRS. HUMBER, LIMITED, ENGINEERS, COVENTRY.

(For Description, see Page 745.)

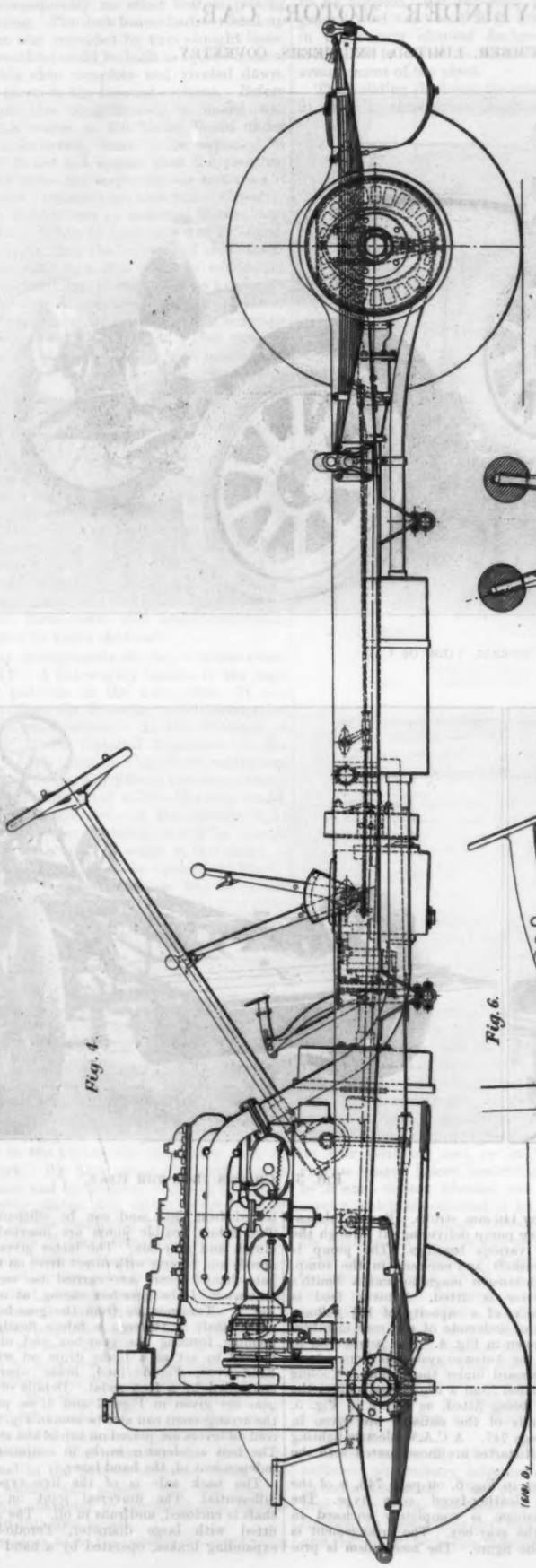


Fig. 4.

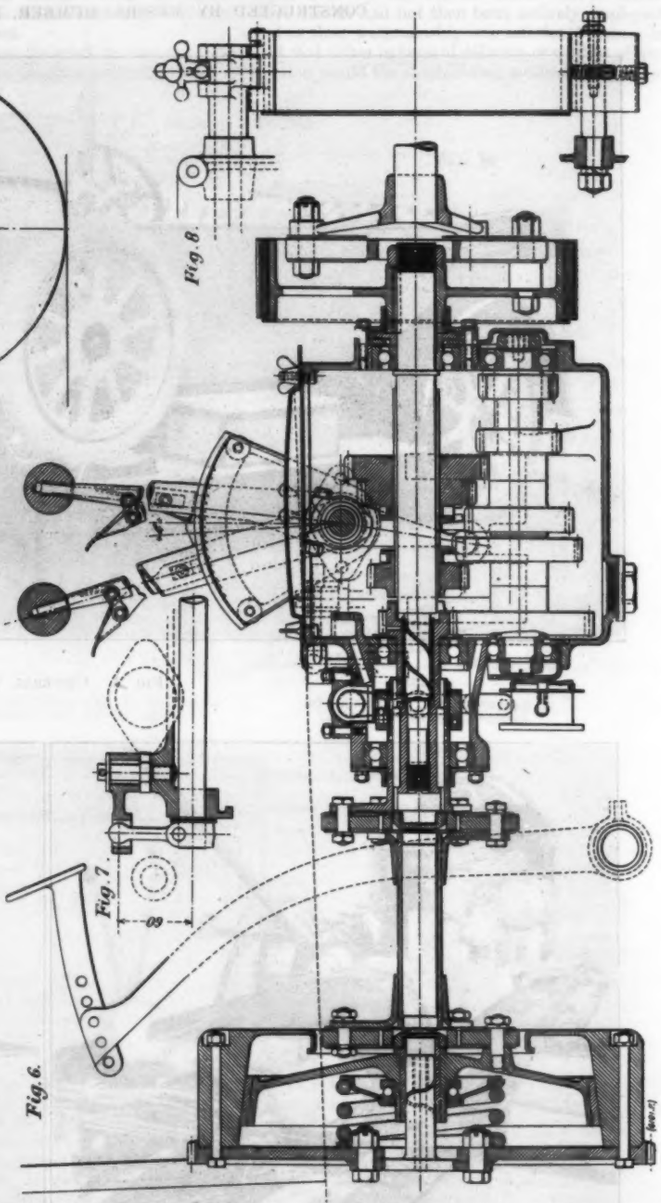


Fig. 8.

Fig. 7.

Fig. 6.

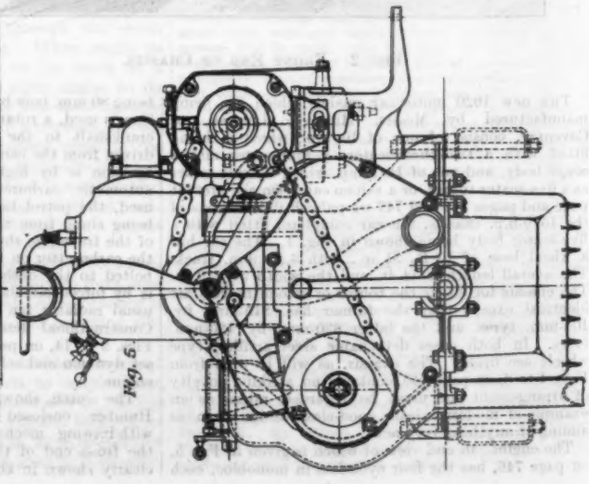
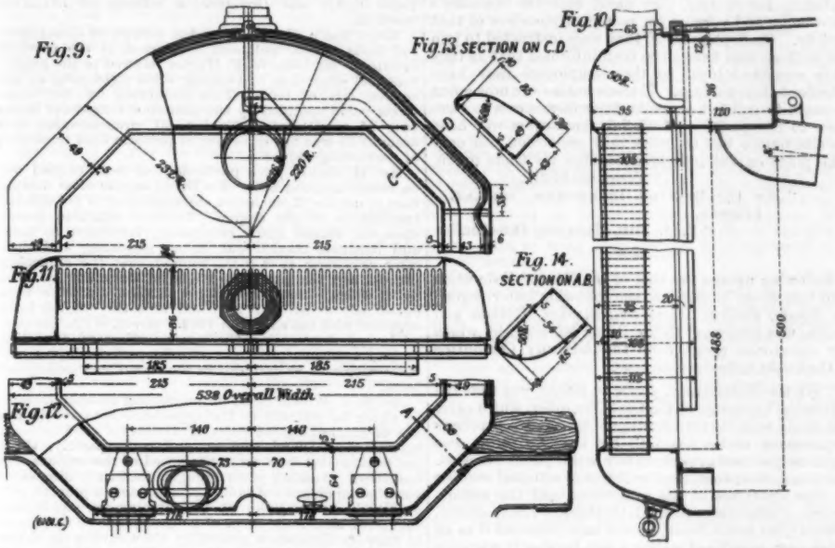


Fig. 5.

RADIATOR FOR 15·9-H.P. MOTOR CAR.

CONSTRUCTED BY MESSRS. HUMBER, LIMITED, COVENTRY.



the gate of the change-speed. The front axle is of H-section and the wheels run on Timkin bearings. Half-elliptic springs are fitted to both front and back axles, as is clearly shown in Fig. 4. The general form of the chassis frame will be gathered from various of our illustrations. As will be seen there is a high up-sweep over the rear axle. The engine and gear-box are mounted on a sub-frame.

THE ALIGNMENT OF CRANKSHAFTS.

THE enclosed multicrank high-speed engine, whether driven by steam, gas or oil, has introduced many mechanical problems peculiar to the type. The greatest amount of engineering discussion usually centres around those problems which the designer has to solve, and if the latter takes a proper view of his responsibilities with regard to simplicity of manufacture and ease of repair, he certainly deserves all the credit he gets for a successful design. But the satisfactory running of an engine is by no means altogether within the powers of the designer to ensure. Not only must the materials and workmanship be good, but proper erection and adjustment are equally necessary. The stresses and speeds in modern engine practice can only be carried safely as long as everything is in adjustment, for there is no margin of strength to take care of the additional stresses due to want of alignment.

The weak spot of all high-speed engines has always been the crankshaft, as many makers know to their cost. At best a crankshaft is not mechanically strong. The varying torque and alternating bending forces which it has to withstand hundreds of times a minute put it to a severe test, while the strength of the crank-webs is continually encroached upon with the desire to get longer crank-pins and journals without increasing the spacing of the cylinders. Hence it is of the greatest importance that it shall be accurately set in the first place, and that any want of support by its bearings, due to wear, shall be promptly remedied. Otherwise serious trouble is only a matter of time. The problem of checking the alignment of the crankshafts of Diesel engines was recently discussed by the members of the Diesel Engine Users' Association, the subject being introduced by Mr. G. E. Windeler, whose great practical experience in the manufacture of these engines entitles him to speak with authority on the subject. Mr. Windeler refers to the necessity of making sure that the bearing shells are properly bedded in the housings before the shaft is tried in. The journals should then be tested for concentricity and roundness, and any such defects remedied either by filing and lapping, or re-machining them. The shaft is then bedded down in the ordinary way, great care being taken to maintain it strictly parallel with the top machined surfaces of the bedplate, as these surfaces control the position and alignment of all the rest of the engine. The foregoing represents the usual procedure when building a new engine or making a thorough overhaul of an old one, but the problem before the engine user is usually presented differently. What he wants to know is whether his engine needs overhauling, or, more specifically, is his shaft properly supported in its bearings, are the latter in a satisfactory state and, lastly, are all bearings, including the outboard one, in alignment?

Mr. Windeler had noted that the first indications of a shaft being imperfectly supported in its bearings were excessive end play and the flywheel running out of truth. Both these signs denoted that the shaft was springing and causing the gaps between the crank webs to open and close. He found that the opening and closing of the crank webs, according to their angular position, could be quite readily detected when the engine was at rest, by the use of a suitable micrometer, the variation of the gap amounts to some thousandths of an inch. The particular value of the method was that it involved no dismantlement of the engine, while the use of a little commonsense indicated which bearing or bearings needed correction. The amount any particular bearing was out of line (excepting the case of the outboard bearing) was found to be approximately equal to the difference between the micrometer readings when the crank-pin was at the top and bottom centre respectively.

The discussion of the subject showed a general opinion that the method was useful in detecting want of alignment and that its employment would do much towards reducing the risk of crankshaft breakages. It was stated by Mr. A. H. Dykes that the crankshafts of the Diesel engines on H.M.S. Benbow were regularly checked in the manner advocated, a special micrometer having been designed for the purpose. It also transpired that Messrs. Bellis and Morcom had used the method for some years, finding it particularly valuable for checking the outer bearings of steam-driven air compressors and engines with overhung flywheels. They found, according to Mr. P. A. Holliday that a point gauge used with feelers permitted satisfactory measurements, a slight indentation being made for the gauge so that measurements could be always repeated at the same place. The only serious critic of the method was Mr. P. H. Smith who, while admitting its usefulness for the alignment of outboard bearings, considered that the alignment problem in general was of such a complex nature that it admitted of no such easy solution as that put forward by Mr. Windeler. Mr. Smith's practice was to measure the thickness of the bearing shell interposed between the journal and the bedplate housing, and he stated that of the many scores of crankshafts re-aligned by him on this principle, not one had ever failed.

This equalisation of the thickness of the bearing shells is undoubtedly the most fundamental way of ensuring that the axis of the shaft is everywhere parallel to the straight surfaces left by the planing machine. It secures a solid level bed at the correct height for each journal, so that when the shaft is bedded into its bearings in the usual way the adequacy of its support can be relied on. But the method naturally involves the complete dismantlement of the engine for the discovery of any deterioration in the alignment of the shaft, and this is an undertaking of such magnitude that it will in many cases be put off until a broken shaft renders it compulsory. Mr. Windeler's scheme is applicable as a test at any time, and whether or not it forms a perfect and complete safeguard against trouble, it most certainly has a most valuable field of usefulness. What all engineers, however, would like to see, is a Diesel engine whose bearings and journals would stand up to their work like those of a high-speed steam engine. The shafts of the latter gave a vast amount of trouble in the early days of the type, but breakages are now a thing of the past so far as the reputable makers are concerned. The stresses and shocks in the Diesel are high, but no doubt the troubles peculiar to the type will be overcome as in the case of the steam engine. Meanwhile the only thing for users to do is to make periodical examinations with the idea of remedying defects before they become dangerous. The excellent records of some Diesel engines built by experienced makers and operated intelligently, holds out hope that in time the reliability of the type will be as highly valued as its economy.

INDUSTRIAL NOTES.

ADDRESSING a meeting of railwaymen last Sunday, Mr. J. H. Thomas, M.P., said it was due to the public to state that while there was nothing which could be called a crisis, the negotiations on wages were not proceeding as satisfactorily as he had hoped. He knew all too well that in one quarter that statement would be construed as an alarming one, whilst elsewhere it would perhaps be called bluff. But he took no notice of either of those views. He was simply announcing what he knew to be a cold, hard fact, namely, that railwaymen were expecting, and were entitled to expect a statement on the question of standardisation before the end of the year. The progress made was not such as satisfied him that this was likely to be accomplished. In any case, the wages proposals now before them were such that they were not acceptable to railwaymen. This did not mean that the last word had been said by the Government. On the contrary, he had strong grounds for hoping that as a result of the further negotiations in view, a more hopeful proposal would be put before them. However, he wanted to impress upon those members who did not hesitate to advocate another strike to settle matters that that was not the way to deal with the situation. On the other hand, it was open to the railwaymen to exhaust every means for arriving at a settlement.

A meeting of the Triple Alliance was held recently, the miners and the transport workers having considered that explanations were due from the railwaymen for declaring the recent railway strike without first consulting the two other members of the alliance. Mr. J. H. Thomas, M.P., told the meeting that the railwaymen had sought a settlement up to the very last moment and when the breakdown came it was too late to utilise the machinery of the Triple Alliance. The outcome of the discussion which took place at the meeting was a determination on the part of the miners, transport workers and railwaymen to act solidly together in future, and none of the organisations comprising the alliance will in future declare a strike without first consulting the other two.

The following is a draft of a 44-hour Bill recently issued by the Boilermakers' Society. This is published in *The Newcastle Daily Chronicle*, which says it is thought the draft in question may be more acceptable to both employers and men than the previous one, as it eliminates a good deal of machinery and officials:—

"Save as hereinafter provided no person shall be employed for a period of more than 44 hours during one consecutive week (that is, the period between midnight on Saturday night and midnight on the succeeding Saturday night), nor for a period of more than 8 hours during any one day.

A person shall be deemed to be employed for the purpose of this Act:—

(*a*) If he agrees for reward to place himself in the service of an employer, or is in the service of an employer, to whose orders, or directions or to the orders or directions of any servant or agent of whom, he is under contractual obligation to conform, or otherwise works under a contract of service or apprenticeship with an employer, whether the contract is expressed or implied, is oral or in writing; or

(*b*) If he agrees, for reward to place himself in the service of an employer, or is in the service of an employer, for the purpose of superintending any person who is under contractual obligation to conform to, or does conform to, the orders or directions of the person so exercising superintendence.

A person or classes of person shall, in any event, be deemed to be employed if the Minister of Labour, by order, specify that such person or classes of person are employed for the purposes of this Act.

In addition to the period of employment allowed by Section 1 of this Act, whether such period be 44 hours a week or less, a person may in case of breakdown or emergency, be employed for a longer number of

hours in any day (hereinafter called overtime), subject to the conditions following :—

Overtime shall only be worked in accordance with an agreement arrived at between the employer and a trade union or trade unions representing the workers concerned ; and

Every person employed overtime shall be paid for each hour or part of an hour of the period of overtime employment at a rate not less than half as much again as the rate paid for each hour worked not overtime during the week in which the overtime is worked.

In computing the overtime worked on any day, the hours worked on any other day shall not be taken into account.

A contract of service affecting payment for overtime contrary to these provisions shall, so far as regards such payment for overtime, be null and void.

Any person employing any other person for a greater number of hours than those authorised by this Act, or failing to pay for overtime according to this Act, or otherwise offending against the provisions of this Act shall be liable, in respect of each offence to a fine not exceeding 20*l.*, and to a fine not exceeding 5*l.* for each day on which the offence is continued after conviction thereof.

Proceedings for offences under this Act shall be brought before a Munitions Tribunal of the second class in like manner as for offences under the Munitions of War Acts, 1915–17, and the provisions of those Acts relating to Munitions Tribunals (hereinafter to be called Industrial Tribunals) and proceedings before them, including the provisions as to appeals, shall apply accordingly.

Provided that proceedings against an employer may be instituted by or on behalf of a trade union and any party to any such proceedings may appear by an officer of a trade union to which he belongs.

On any prosecution of an employer under this section, it shall lie on the employer to prove, by production of proper wages or time sheets, or other records of time worked or wages, or otherwise that he has employed the person in question a number of hours not more than the permitted period.

Any agreement for the employment of any person in contravention of this Act shall be void.

Nothing in this Act shall be construed to be in derogation of any other Act, Order or Regulation which fixed maximum hours of employment of any person which are shorter than those provided in this Act."

Speaking at the meeting of shareholders of the Cargo Fleet Iron Company, Limited, held last week at Middlesbrough, the chairman, Viscount Furness, said : ". . . he need scarcely say that the present year had been one of very great anxiety to the directors and officials owing to strike troubles, and the general labour unrest. Their output had been greatly interfered with by the various strikes, including the national railway strike and the engineers' strike, to say nothing of the shortage of coal and the shortage of railway trucks for the conveyance of both their raw and finished materials. He felt it his duty to sound a note of warning to all who were interested in the maintenance of their industry as well as all other important manufacturing industries in this country. Unless labour could settle down to steady regular working conditions and give a fair output for a fair day's wage it would be impossible to obtain the necessary increased output to enable them to compete to advantage for export trade in the markets of the world, which was so essential to their national supremacy from the commercial and industrial point of view. Employment had been found for the whole of the returned soldiers capable of taking up their duties. They were also endeavouring to adjust various classes of work in order to enable them to find employment for permanently-disabled soldiers, and while such employment would naturally be first offered to old employees they were hoping that their efforts would result in absorbing not only all their own men, but also others who had been disabled and who might find themselves less fortunately placed. With regard to the general prospects, they were difficult to predict, as it could not be denied that they would be up against very serious competition from other countries as soon as they had passed through the period of reconstruction. It was therefore essential in the national interest that everything possible should be done to increase output and to reduce cost of production.

A letter to the editor of *The Times*, entitled "Trade Union Victimisation," and published in the issue of that journal for November 28, deserves to be put on record. It reads :—

"Sir,—I desire to draw your attention to two cases of trade union victimisation in connection with our officials. Two of our employees who have been contributing for some thirty years past weekly payments towards the old-age superannuation fund of the Friendly Society of Iron Founders have by their own merits risen from the ranks and become officials in charge of their respective shops. In order not to lose the old-age benefits to which they have been contributing for so long, they have, with the company's knowledge and permission, remained members of that society. On September 20 they were instructed to join the strikers, and have since been informed that as they have remained loyal to their employers they have sacrificed their savings. If trade unions are now going to begin to call out on strike their members who have risen to the position of officials, employers will have no alternative but to insist that promotion can only take place on the individual leaving his trade union.

"Yours faithfully,

"For the Stanton Ironworks Company, Limited,

"E. J. Fox, Managing Director."

Following upon a meeting of the Miners' Federation held last week, in London, the following letter, signed by Messrs. Smillie, Hartshorn, Straker, Robson and Smith, was addressed to the Prime Minister, by which the signatories resign from the Advisory Committee of the Coal Controller :—

"We the undersigned, desire to inform you that the Advisory Committee to the Coal Controller, which came into being with the introduction of the Coal Controller's Department under the late Sir Guy Calthrop, has apparently ceased to perform any useful public function. The committee, comprised as it was of an equal number of representatives of the coalowners and the miners, proved of great value to Sir G. Calthrop. His successor, however, Sir Evan Jones, cannot have regarded it as an instrument capable of assisting him because it was only called together twice to discuss trivial matters remote from the great questions which have from time to time arisen in the coal-mining industry.

"The President of the Board of Trade has made decisions affecting the industry which could never have been arrived at had he called to his assistance not only the Coal Controller, but the Coal Controller Advisory Committee. These decisions, such as the raising of the price of coal, and the reduction in the price of coal, have gravely prejudiced the industry and the nation, and such decisions could never have been arrived at had he chosen to obtain the expert advice of the Advisory Committee.

"His latest proposals for limiting the sphere of operations and influence of the Coal Controller, in conjunction with the foregoing, render it impossible for us to continue to sit and act upon the Advisory Committee. We, therefore, ask you to please accept our resignations from this body, which is a step in which our Executive Committee fully concur."

A ballot which has been taken of the South Wales miners on the question of declaring a strike to resist the payment of income-tax on wages not exceeding 250*l.* per annum showed the following figures :—

For a strike	73,307
Against	72,837
Majority for	470

It is stated that over 20,000 members of the federation failed to record their vote.

It is reported that the Executive of the Dock Labourers' Union have decided that henceforth every man working at the docks and coming within the definition of dock labourer must be a member of the union, and; further, that those who henceforth join the union must pay an entrance fee of 5*l.* There are, however, two exceptions to this rule, applicable to demobilised men who were dockers before the war and who will join free, and the sons of existing members who will join on paying 10*s.* only. This step applies to the Liverpool Docks, and the assistant secretary, Mr. G. Milligan, stated that it had been taken in consequence of the increasing number of men who were presenting themselves as dock labourers. This threatened to cause a good deal of unemployment in the docks. There were large numbers of men who had not gone back to their original trades, and it was unfair that these should come forward to compete for dock labourers' work. A clearing-house system was in operation before the war in order to regulate the flow of labour, and the heads of the union had since endeavoured to prevent the supply becoming greater than the demand.

The Mining Institute of Scotland.—The headquarters and library of this Institute have been removed from 39, Elmbank Crescent to the Royal Technical College, George-street, Glasgow, and all communications should be addressed to the Secretary at that address.

THE DIESEL ENGINE USERS' ASSOCIATION.

At the meeting of the Diesel Engine Users' Association on November 20 the Hon. Secretary reported the progress that had been made in forming the Provisional Committee for the proposed Research Association for Liquid Fuels under the Government scheme of industrial research.

There was a discussion on the subject of Connecting-rod bolts, which had been considered at the previous meeting. Mr. Geo. W. F. Horner referred to the greater torsional effect due to twisting when tightening up the smaller size of bolts. This accounted for the lower stress value specified by the insurance companies in the case of small bolts. Taking all circumstances into account he was not in favour of periodic heat treatment of connecting-rod bolts.

Mr. H. Squire gave particulars of tests carried out on connecting-rod bolts of a Diesel engine after having been in use for 23,500 hours, corresponding to 214,000,000 revolutions of the engine. Tests of ultimate tensile strength, elastic limit, elongation, reduction in area, and hardness carried out before annealing and then after annealing at 900° C., showed that the annealing process had practically no effect on the material. The bolts, which were $1\frac{1}{8}$ in. at the smallest diameter, were apparently of wrought iron and were the original bolts supplied with the engine in 1913. Mr. A. W. A. Chivers, while not deprecating the general effect of annealing or heat treatment, did not consider periodic heat treatment necessary or desirable in the case of connecting-rod bolts.

Mr. A. J. Wilson made an interesting communication, in which he referred to the experience obtained in the use of connecting-rod bolts of 31–35-ton steel on submarine type Diesel engines, and, subsequently, three per cent. nickel steel when the speed of the engines was increased. Another point brought out in the discussion was the importance of taking precautions to prevent any overstrain on the bolts when tightening up, and it was suggested that some form of gauge should be employed to note the elongation caused by the screwing up of the nut.

THE NON-FERROUS MINING COMMITTEE.

The committee appointed by the Board of Trade to inquire into the non-ferrous mining industry in the United Kingdom has held several meetings under the chairmanship of Mr. H. B. Betterton, M.P., and has examined a number of witnesses.

Mr. A. F. Maclaren, chairman of St. Ives Mines, Limited, said that the Giew Mine was the only mine now working in St. Ives district, and this was working at a loss. The mine lost a large proportion of its men at the beginning of the war by the calling up of naval reservists, and insufficient development work was done in consequence ; this was retarding operations now. He thought that the Giew Mine and its immediate neighbours could be equipped for work on a sufficient scale for an expenditure of 40,000*l.* and that a profit could then be made if the price of metallic tin were not less than 220*l.* a ton. He estimated that it would require 180,000*l.* to restart the St. Ives Consols group, and thought it would not be possible at this time to raise the money required for such purposes by the usual means.

Mr. E. Terrell gave evidence respecting Wheal Jewell, Wheal Friendship and Hemerdon Mine. Underground working at Wheal Jewell was suspended in 1916 owing to the scarcity of labour. He was convinced from the yields of tin and arsenic obtained during development that the mine was a sound commercial proposition under ordinary economic conditions, but he thought the outlook at present speculative and not encouraging. The Hemerdon Mines, Limited, opened a large area to supply the war demand for wolfram. Small quantities of wolfram have been produced and working results have been very promising. By January, 1919, a plant capable of dealing with large quantities of material had been completed at a cost of 75,000*l.*, but the heavy drop in the price of wolfram caused the closing of the mine in April. Mr. Terrell did not think his directors would be justified in resuming operations under present conditions with a price for wolfram below 55*s.* per unit.

Mr. J. A. Stephens and Mr. W. Barrett, representing the members of the Workers' Union in the Camborne District, gave evidence on the labour side. They referred to the patience of the Cornish miners, who had received smaller increases of pay than any similar class of men in the country, and thought advances in wages should be made immediately. They were of opinion that the heavy increase in the cost of materials used, without a corresponding increase in the price of tin, had prevented the mines from carrying on necessary development, and the output was consequently too small for economical working. They thought the equipment of many of the mines, especially in regard to the shafts, would require replacement before the output could be materially increased.

Sir Cecil Budd, K.B.E., chairman of the London Metal Exchange, and Mr. R. W. Rucker, who occupied official positions under the Ministry of Munitions during the war period, explained the nature of the war-time control of tin, lead and zinc, and gave evidence on the subjects of the general movement of market prices, and the world production of these metals.

Mr. D. Gill Jenkins advocated the establishment of a Mining Records Office, and discussed his plans for dredging for tin in St. Ives Bay.

Mr. W. H. R. Chappel, of Messrs. Osborne and Chappel, gave evidence respecting the present and prospective contribution of the Federated Malay States to the world's tin supplies.

Mr. Oliver Wethered, vice-chairman of the Cornish Chamber of Mines, vice-chairman of Dolcoath Mine,

Limited, and chairman of the Geevor Tin Mines, Limited, explained the present position and prospects of the Dolcoath, Killifreth, Porkellis and Geevor mines in Cornwall, and gave his views as to the future of the Nigerian tin industry. He thought that all the available evidence supported the view that the production of the known tin fields of the world could not expand to meet the inevitable increase in demand for the metal, and was of opinion that high prices for tin would probably rule for some time to come. With regard to Cornwall, he thought there were possibilities of large and profitable production at the prices to which he anticipated tin would go, but he expressed the opinion that some immediate help was desirable to overtake development work which had fallen behind during the war, and also to assist in the opening up of new ore bodies for the existence of which there was geological evidence. He suggested a loan at a low rate of interest with repayment deferred for at least twenty-five years.

Mr. G. Bargate, assistant manager of the Dolcoath Mine, outlined the history of the mine, the records of which go back to 1776, and showed that extensive developments, particularly lateral, were necessary to enable the mine to work profitably in future. He explained the scheme for developing the northern and western areas owned by the Dolcoath Mining Company, and gave estimates of the cost of opening up the northern lodes by a cross-cut from the present mine.

Mr. J. H. Bennetts, on behalf of the Workers' Union, and Mr. W. Hosking, Mr. H. Hosking, Mr. W. Richards and Mr. J. Nankervis on behalf of the Dock, Wharf, Riverside and General Workers' Union, gave evidence on Cornish tin-mining from the workers' point of view. They thought that State aid was necessary to enable the mines to carry out developments and, in some instances, to instal modern machinery to increase production. They claimed that, having regard to the low wages now paid, the workers had the first claim on any prosperity that might result to tin-mining from Government assistance.

Major Tudor Trevor, inspector at Pretoria for the South African Department of Mines, gave evidence relating to the mining laws of South Africa, and explained the duties of his department and the methods by which the South African Government assisted the mining industry.

"USE OF OPTICAL PYROMETERS FOR CONTROL OF OPTICAL GLASS FURNACES."

To the Editor of Engineering.

SIR,—On returning to Washington a few days ago, after an absence of several months, I found a copy of your journal of August 22, in which is reprinted (on page 256) my paper on "Use of Optical Pyrometers," from the Bulletin of the American Institute of Mining and Metallurgical Engineers. In this article your typesetters have made me responsible for a statement which is a little absurd, although the error is not very serious. In column 2, lines 17 and 18, the article reads as follows: "it may reflect an image of the sun, for instance, representing a temperature of, say, 1,000 deg. . . ." If you will kindly consult the paper as it appears in the Bulletin you will see that the statement there reads: "it may reflect an image of the sun, for instance, representing a temperature of many thousand degrees; or, it may be heated to a temperature of, say, 1,000 deg. . . ." By the omission of a few words I appear to attribute a temperature of only 1,000 deg. to the sun.

In the last paragraph of the article also there is an error, but for this you are not responsible. The lines reading "with the hours of the day in which are printed along the bottom . . ." should read "with the hours of the day printed along the bottom . . ." In some manner the entirely meaningless expression "in which are" became inserted after the corrected proof had been sent to the editor of the Bulletin.

Will you kindly print in your journal a note of these corrections?

Yours truly,

C. N. FENNER.

Carnegie Institution of Washington, Geophysical Laboratory, Washington, D.C., November 1, 1919.

[We regret the error: it was due to a complete line of the paper being omitted.—ED. E.]

"THE BRINELL AND SCRATCH TEST OF HARDNESS."

To the Editor of Engineering.

SIR,—With reference to the note which appeared in your issue of November 21, and with the sincerest respect for the views and achievements of its distinguished author, may I be allowed to quote from two early authorities on scientific procedure?

Dr. Robert Hooke, writing soon after the Restoration on "*The Present State of Natural Philosophy*," says:—

"And some that have indeavoured to make use of Arguments rais'd from the Experiments, and Observations, have been so confounded with them, for want of a Method of proceeding; that they have been to little purpose, save the putting of Men upon new Tryals, whereby perhaps some useful Experiment has been light upon, and thereby some latent Error in the former Theories detected. For neither having a true idea of making Observations and Experiments, nor a convenient way of ordering, nor a right Method of using them, the greater number of them they have, the more are they confounded."

Dr. Unwin, whether "confounded" or not, takes the course indicated by Hooke and suggests "new Tryals."

Lord Bacon, in the *Novum Organum*, writes:—

"Four species of idols beset the human mind: to which (for distinction's sake) we have assigned names: calling the first Idols of the tribe; the second Idols of the den; the third Idols of the market; the fourth Idols of the theatre . . . . The idols of the market are the most troublesome of all, those namely which have entwined themselves round the understanding from the associations of words and names. For men imagine that their reason governs words, whilst, in fact, words react upon the understanding; and this has rendered philosophy and the sciences sophistical and inactive. Words are generally formed in a popular sense, and define things by those broad lines which are most obvious to the vulgar mind; but when a more acute understanding, or more diligent observation is anxious to vary those lines, and to adapt them more accurately to nature, words oppose it. Hence the great and solemn disputes of learned men often terminate in controversies about words and names, in regard to which it would be better (imitating the caution of mathematicians) to proceed more advisedly in the first instance, and to bring such disputes to a regular issue by definitions . . . ."

"Take some word for instance, as 'moist'; and let us examine how far the different significations of this word are consistent. It will be found that the word 'moist' is nothing but a confused sign of different actions admitting of no settled and defined uniformity. For it means . . . ."

"There are, however, different degrees of distortion and mistake in words. One of the least faulty classes is that of the names of substances, particularly of the less abstract and more defined species (those then of 'chalk' and 'mud' are good, of 'earth,' bad); words signifying actions are more faulty, as to 'generate,' to 'corrupt,' to 'change'; but the most faulty are those denoting qualities (except the immediate objects of sense), as 'heavy,' 'light,' 'rare,' 'dense.' . . . ."

Would it not be better to define "hardness," and many other qualities, before attempting to measure them?

Yours faithfully,

JOHN INNES.

12, Edward's Road, Whitley Bay, Northumberland. November 29, 1919.

ROYAL ENGINEER VOLUNTEERS.—The London Army Troops Companies have ceased to exist, as under War Office instructions, all non-commissioned officers and men were discharged on September 27. The officers, with the exception of the commanding officer, relinquished their commissions on October 17. The commanding officer is now the sole official representative of the corps. It is expected that there will be a balance of the funds available for charitable purposes.

PERSONAL.—Messrs. Robert D. McCarter and William L. Cooper announce from 165, Broadway, New York, that they have formed a partnership and that their consulting engineering and purchasing for clients will be conducted under the name of McCarter & Cooper. Messrs. Anthony Brown & Hooghwinkel, Ltd., 24, Martin Lane, Cannon Street, E.C. 4, state that they have concluded a working arrangement with Messrs. McCarter & Cooper.—The Monometer Manufacturing Co. (1918), Ltd., Furnace Makers, Engineers and Iron-founders, have removed their works from Whitehouse Street to Browning Street, Birmingham. The Monometer Co. are also the proprietors of the Griffin Ironworks and Albion Foundries, Browning Street, Birmingham. The railway siding for the Monometer Works and foundries is Monument Road Station, L. & N.-W. Railway, and their canal siding is on the Staffordshire Canal.

ON THE MICROSTRUCTURE OF CEMENT AND CONCRETE.—In the course of his presidential address to the Concrete Institute, on November 27, Mr. H. D. Searles-Wood stated that the Science Committee was considering the question of the investigation of cement by means of micro-sections, and in due course a report of this would be forwarded to the Research Department. It was generally known, he added, that a good cement, under favourable conditions, tended to increase in strength with age, and that the action of setting in such increase in strength was due to hydration. There appeared, however, to be but few data available as to the actual change in form of the various components of concrete from a microscopic standpoint, although it was understood that American and German scientists had already carried out some investigations. That chemical changes took place in the progress of setting was proved by chemical analysis, but the analyses remained to be properly co-ordinated with the micro-structure of the cement or compo during the process of hydration. Mr. Searles-Wood also said that watertightness was one of the most important requirements of cement and concrete, more particularly in connection with reinforced concrete, and in connection also with their use either in the form of mass concrete or as reinforced concrete for tanks of vessels for containing or excluding liquids. Percolation tests on ordinary concrete had shown beyond question the fact that even with clean, filtered water all concrete tended in time to become less porous, provided the pieces under test were kept moist, thus proving that the chemical changes produced alterations in the micro-structure tending gradually to fill the small voids with crystalline growths. How these crystalline growths developed was a matter which it was desirable should be carefully investigated, and the only satisfactory method which presented itself at the present time was by examination of the micro-structure of cement and cement compo during development.

APPLICATION OF PULVERISED COAL IN BLAST FURNACES.*

By E. P. MATHEWSON and W. L. WOTHERSPOON.

(*Concluded from page 697.*)

EXPERIMENTS have been made with a number of ejectors, the design of which is important, when giving consideration to economy in the use of compressed air. Easily-constructed ejectors may be made from standard pipe fittings by proportioning the sizes, but the size and proportion of the inlet of the compressed air to the discharge of the ejector is a most important feature. Some of the ejectors used are shown in Figs. 11 to 15.

In commencing the experiments the air blast for the combustion of the coal and for smelting was furnished in the regular way under normal operating pressure, and the pulverised coal was introduced directly into the blast before entering the tuyere. It was found that the coal could be introduced very rapidly in this way while the furnace had its regular charge of coke and ore, but when the coke was cut below 50 per cent. of normal, it was found that the tuyeres became closed, coal dust would lodge in the tuyere pipes, and a certain quantity would find its way into the bustle pipe, causing trouble at any leaky joint, thus rendering the condition around the furnace more or less dangerous. At this time the joints between the furnace jackets and the tuyeres were not as tight as they should be, and there was considerable leakage of coal dust. Tuyeres of several designs were tried to avoid leakage, and the canvas sleeves on the branch pipes were replaced with 5-in. standard pipes, having flexible joints. Improved results were obtained in this way, and some of the tuyeres used are illustrated in Figs. 16 to 19. Later on, the coal was introduced to the blast by means of an ejector like that used by Mr. Cavers at the Tennessee Copper Company (Figs. 20 to 22).

During this stage of the experiments, the main troubles were at the tuyeres, which required regular punching, and there was some leakage of coal. The coal was applied to only half the tuyeres on each side of the furnace, being introduced to alternate tuyeres, those on the front of the furnace being staggered in relationship to those at the back. Mr. Garred experimented with check or explosion valves which were placed in the branch pipes. It was found these check valves were not effective except when they were carefully designed and placed in every branch pipe, and this was a complication of apparatus that was not considered desirable. It was then found that if any individual tuyere was choked, the coal was drawn into the bustle pipe by suction and found its way down the branch pipes leading to tuyeres that were open. It was therefore agreed that any possibility of explosions could be effectively prevented by arranging check or explosion valves in the bustle pipe itself. The experiment was then made of introducing the coal between and slightly above the tuyeres, by boring a hole through the jacket and connecting to these the coal supply pipe from the ejectors at the screw feeds, thus introducing a dense mixture of coal and air into the furnace independent of the main air supply. This was found to be a clean method, and a test was made over a period of eight days. During this time the coke was reduced from 12 per cent. to about 6 per cent., with promising results; the most important and necessary condition still being that of keeping the tuyeres open. It was observed that the small openings (1¼-in. pipe) through which the coal was introduced into the furnace required very little punching, the main trouble being with the large tuyeres; and by observation through the Dyblie valve, the combustion and the smelting of the ore in the furnace could be seen in operation.

It was decided to use specially-designed furnace jackets at the tuyere level of the furnace. The design finally adopted is shown in Figs. 23 and 24.

These jackets, it will be seen, provide means for a more even distribution of the blast, and it was thought that they would give better opportunity for combustion at the entrance to the charge. It was also believed that furnace jackets designed on this principle would not be more expensive than those of regular design, as two tuyere castings with their joints and machine work could be dispensed with. The furnace is now equipped with some of these jackets, but it is too early to state, definitely, how advantageous they are.

Experiments have been made with a standard blast furnace reduced in width from 52 in. to 36 in. at the tuyere level, with the air blast at various pressures, and melting a variety of furnace charges. Considerable study has also been given to modifying the design of furnaces in order to obtain ideal conditions in smelting. Fig. 25 illustrates one of these modifications, which it was found could be easily obtained by changing the section of the jackets in the existing furnace at the International Nickel Company's smelter. These modifications, it is believed, will be advantageous for the following reasons:—

1. There will be produced, mechanically or artificially, a condition wherein the melting zone is fixed in proper relation to the combustion and charge.

2. The tuyeres will be free and unobstructed, giving improved conditions with reduced costs.

3. The most efficient use of air blast will be possible, on account of its complete control, regulation and distribution.

4. There will be a combustion chamber and tuyeres so arranged that any gaseous fuel can be used efficiently; among such gaseous fuels may be included pulverised coal and atomised oil.

5. The furnace construction will cause the gases

* Paper contributed to the Canadian Mining Institute. Part of vol. xxii.

from the combustion chamber to be distributed efficiently to the furnace charge. Combustion arrangements are such that positive ignition of all the fuel is assured.

6. The molten mass in the crucible will be strongly heated to facilitate the separation of the metals.

7. The furnace construction can be so arranged that concentrates, flue dust, fines, &c., can be smelted economically and with minimum losses by being introduced into the lower part of the furnaces by means of the tuyeres or other suitable connections.

8. There will be the utmost economy in the use of air blast, with resulting economies in power, and there will be a greater efficiency in the use of oxygen, due to the preheating of the gases and their better distribution.

9. The furnace may be rectangular or circular, with the melting zone arranged correspondingly.

10. With a furnace of this design, combustion occurs at the base of the furnace charge, thus obtaining the most efficient use of the heat and gases.

11. The furnace design provides facilities for repairs to the lower portion of the furnace without resorting to the usual procedure of shutting down and digging out the whole of the furnace charge.

To summarise the results of the experiments at Copper Cliff, it can be said that under difficult conditions, and without interfering with production in the slightest, it has been demonstrated that important economies are possible at many smelting plants by the utilisation of pulverised coal, thus replacing a considerable portion of the coke, and the International Nickel Company, early this year, decided that an aggressive policy of experimentation and development should be followed.

Influence on Operating Conditions and Cost.—It is a foregone conclusion that the characteristics of the charge will have an important bearing on the results obtained. At Tennessee the charge consists of run-of-mine ore and quartz in large pieces, with a high percentage of sulphur, and melting conditions that call for relatively small quantities of fuel. At Copper Cliff, the ore is comparatively fine, over 75 per cent. of the charge coming from the roasting beds, from which it is reclaimed and handled two or three times, and the final sulphur content does not much exceed 12 per cent.

There are some blast furnaces operating in conjunction with reverberatory furnaces, where the blast-furnace charge is favourable for easy smelting conditions, due to the slags and other by-products being treated therein. It is generally believed by those conversant with the experiments that successful work at Copper Cliff can assuredly be followed by successful work in a large proportion of the blast furnaces smelting non-ferrous ores elsewhere.

Regarding blowholes in the charge, it appears that these should be less when utilising pulverised fuel than under normal operating conditions, as segregations of the coke are, to a large extent, responsible for the blowholes. For the same reason, beneficial results might also be anticipated regarding dust losses.

It is often stated that large pieces of incandescent coke are necessary in the charge to support the burden. This may be so under certain conditions, but the experiments indicate that it is not essential in smelting copper sulphide ores, and we do not expect it to be a matter of great moment when treating other non-ferrous ores.

Another point of great importance is the effect of the Garred-Cavers process on the tuyeres and the amount of tuyere punching. Tuyere punching, under normal conditions, entails a good deal of hard labour, and it is our opinion the conditions in this connection will be greatly improved. The moisture content in the charge may be high without causing trouble; during the experiments several charges of wet fines, the clean-up from storage bins, having been handled without trouble.

In the preparation of pulverised coal it is customary first to reduce the run-of-mine product, when this is used, to about 1 in. in size, preparatory to drying, and then to reduce the powder in pulverisers. The first precaution should therefore be to remove any iron or steel from the coal, by means of magnetic separators.

The next precautionary measure is to employ a type of dryer that does not allow the coal to accumulate in large settling chambers; to guard against overheated bearings, and to have the dryer fired and controlled in such a manner that its temperature is under control at all times. It is also important, in arranging conveyors and elevators, to see that pockets and other spaces are not left for the accumulation of pulverised coal.

Coals high in sulphur and moisture content are liable to spontaneous combustion, and it is therefore advisable that bins should be made of metal, totally enclosed, with no corners or pockets where the coal is likely to lodge and stay for any length of time. Storage capacity should be as small as possible, compatible with uninterrupted service.

Danger of explosion occurs when the atmosphere is charged with finely-divided fuel, and overheating, through accidents or negligence, causes combustion. It is claimed that sparks alone will not ignite the coal dust air mixture.

Pulverised coal is much safer than oil or natural gas, as a leak is easily detected by the eye, and the trouble can be quickly remedied. The entire system, from the point where the coal is dried, to the tuyeres at the furnaces, can be entirely enclosed, and the bins and conveying system contain but a small quantity of air, so that the danger of explosion is negligible.

It is safe and good practice to blow pulverised coal through comparatively small pipes, and there are several successful installations, where the fuel is transmitted long distances by the Bonnot system; the coal being carried in suspension, with about one-third of the volume of air necessary for combustion.

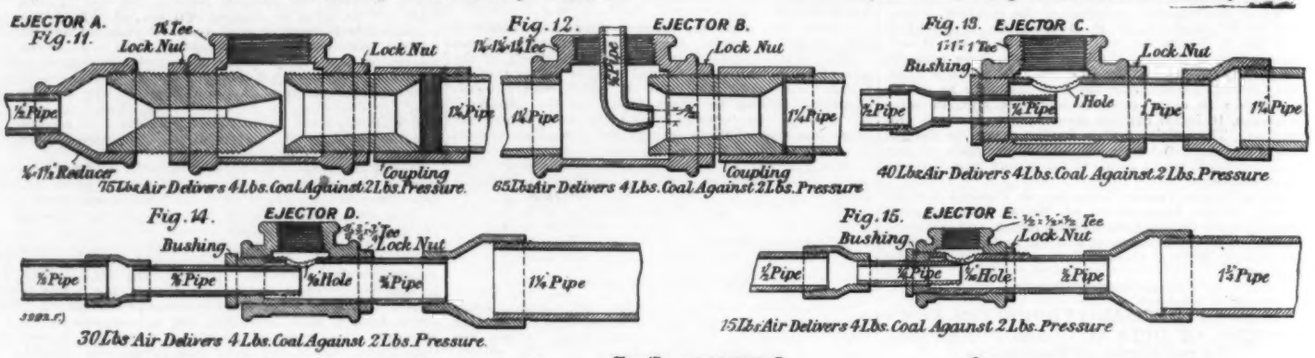
With blast-furnace tuyeres in good condition for operating there should be no risk of explosion, but check and relief valves should be installed to guard against such a contingency, in the event of interruption of the blast pressure. Automatic controllers should be used to stop the coal feed under such circumstances.

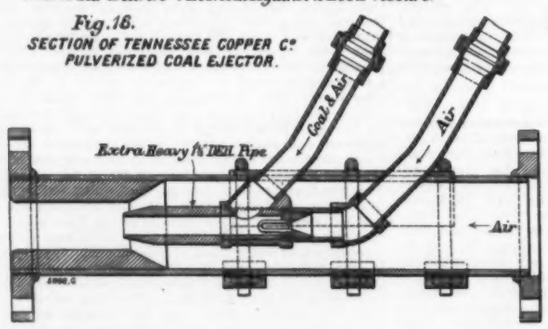
Regarding the ratio of furnace capacity to hearth area: It is too early to state anything definite.

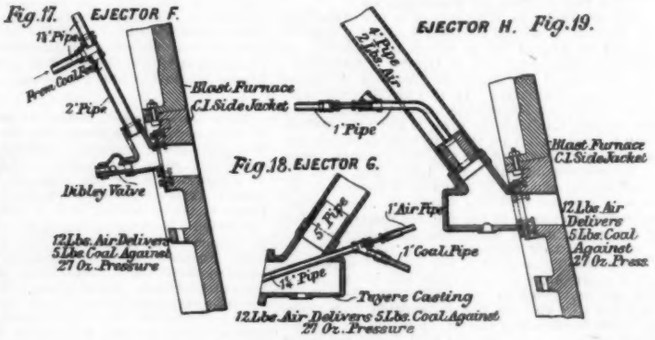
There is consumed, in the United States, about 10,000,000 tons of pulverised fuel per annum, and its use is still further being increased, so there is now an established practice in the preparation of the fuel.

The most important influence on operating costs is in connection with the fuel utilised, the normal practice being to use coke alone, whereas these experiments show that coke can be replaced, to a large extent, by pulverised coal. The relative costs of coal and coke vary a great deal, but, on the average, coke may be stated to cost twice as much as coal delivered at the smelters. It is only necessary to refer to the fuel conditions in Canada to appreciate this phase of the problem. For instance, the International Nickel Company of Canada, Limited, consumed, in connection with their blast-furnace plant at Copper Cliff, during the last few years, about 300 tons of coke per day, the average cost of this product being (during the fiscal year of 1915–16) 6·25 dols. per ton. The price of high-grade bituminous coal, as used by them in connection with reverberatory furnaces had a corresponding cost of 3·50 dols. per ton of slack. Up to the present, high-grade bituminous coal has been used in the experiments. The average analyses of this coal during the month of August, 1918, which average may be said to be fairly representative, was: Fixed carbon, 51·85 per cent.; volatile matter, 36·10 per cent.; ash, 12·05 per cent.; and sulphur, 3·28 per cent.—fineness, 93 per cent. to 94 per cent., to pass a 100-mesh screen, and 75 per cent. to 85 per cent. to pass a 200-mesh screen. It will undoubtedly be possible, however, to develop the use of a large variety of pulverised fuel for blast-furnace operations, as has been the case with boilers and other types of furnaces. Lignite will be suitable in many localities, among which are certain portions of Canada, Mexico and Burma.

In blast-furnace smelting of copper ores, the ash content of the fuel is of minor importance, and the more erosion in a furnace charge the greater the efficiency, so that these two factors connected with the use of pulverised coal, which are discussed so freely in connection with other furnace applications, are here of little significance. The influence on power costs should be favourable, owing to the increased efficiency in the







furnace, and the possibilities of more regular charge, reducing the wastage of air. The amount of power used for applying the coal at the furnace is small, being confined to the feeders and other apparatus, such as ejectors, &c. The air supply will naturally vary according to the character of the furnace charge and the height of the column that is found to be advisable. The present work has been carried on with the same air pressure and the same height of charge as is usually employed at these smelters; but if higher pressures are utilised, it is anticipated that the additional cost of power will be more than met by the increased efficiency in the smelting operation.

The introduction of the fuel at the tuyeres gives considerable relief on the charge floor of the furnace, and in a large smelter, should have favourable effects on the cost of tramming; the coke being usually handled in cars or other mechanical devices, from storage bins, and this requires an appreciable amount of labour, power and equipment.

The cost of preparing pulverised coal will vary considerably, as there are several factors bearing on the matter, among which are labour, power, fuel for dryer, repairs, in addition to interest and depreciation on buildings and equipment.

The power required for crushing, drying, elevating and conveying the pulverised coal will be about 20 h.p. hours per ton of coal handled, and with modern equipment under average conditions, the cost will be about 8 cents per ton per hour.

The cost of operating the dryer will depend upon the cost of the fuel, as the amount required per ton of coal dried, with a given moisture content, with standard dryers, will not vary much.

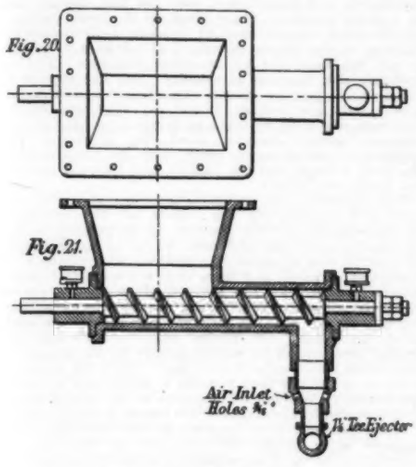
The cost of labour will be directly affected by the equipment installed and the size of the plant. The costs from several plants, with a capacity of from 5 tons to 10 tons per hour, varies considerably. The records for 1912, at the American Iron and Steel Manufacturing Company, of Lebanon, Pennsylvania, show 40 cents per ton for the actual preparation of the coal, on a basis of 150 tons to 200 tons per day, and 20 cents

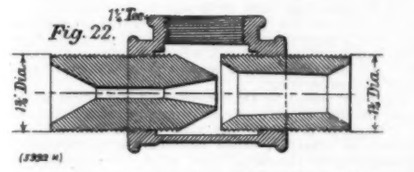
for the conveying system, which, in their case, is of an extensive character, owing to the large number of furnaces to which pulverised coal is applied. The details are as follows :—

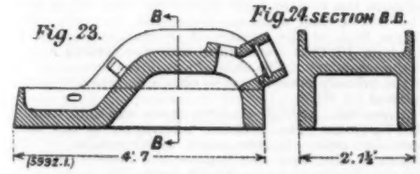
	Rate per Ton of Coal Produced. Dols.
Fuel	0·034
Repairs to buildings	0·002
Operating	0·145
Power (steam and electric)	0·221
Repairs to machinery and equipment	0·200
Total	0·602

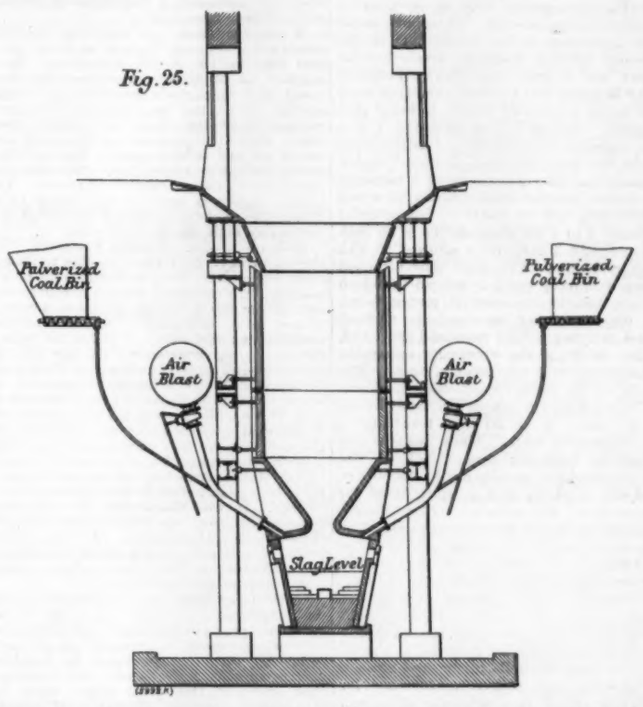
The preparation of lignite calls for more attention than that of other fuels, on account of the high moisture content, which is frequently in excess of 50 per cent., and on account of the large amount of volatile constituents. It is usual to reduce the moisture to about 6 per cent.; to attempt further reduction is to invite trouble in the way of fires and excessive dryer costs, and all to no avail, because it will again absorb this much moisture from the atmosphere. Various tests show that lignites lose 2½ per cent. of their volatile combustible matter, when exposed to a temperature of 284 deg. F. for a period of 30 minutes. Such losses cannot be allowed, and so the drying must be done at lower temperatures, and therefore with increased equipment; recent practice being to arrange the dryers in series.

	dols.	dols.
Three 57-in. mills with pulley drives, motors and belts	31,260	
Steel platforms, runways and stairs ..	4,000	
Discharge spouts from mills	300	
10-ton crane	1,500	
Screw conveyor with motor drive ..	620	
Conveyor cover, exhauster, dust collector and piping	1,900	
Wiring and installation of motors ..	4,000	
Machinery foundations and floors ..	3,150	
Excavations	1,000	
Miscellaneous erection, labour ..	3,750	
		85,458
Total		101,538
Engineering, 10 per cent.		10,150
Grand total		111,688









At the International Nickel Company's smelter, the average cost of preparing and delivering the coal to the furnace in 1913, was as follows :—

	Dols.
Labour	0·15
Power	0·10
Repairs	0·145
Coal for drying	0·055
Total	0·45

The present costs are abnormal, due to war conditions, and will undoubtedly be reduced in the near future. They are as follows :—

	Dols.
Labour (six months)	0·384
Power (June to November, inclusive, 1918)	0·084
Repairs	0·284
Coal for drying (101 tons per day average)	0·108
Total	0·86

In this connection it may be stated that the cost of drying is excessive, because the moisture content of the coal averages about 10 per cent., and that the amount of abour employed could conveniently prepare a much arger tonnage of coal.

The item "repairs" includes all repairs to coal crackers, grinders, conveyors, fans, belting, &c. Four men on an 8-hour shift are all that are necessary to prepare and deliver 100 tons to 200 tons per day.

The costs in connection with lignite are, of course, greater than with other fuels, due to the large increase in dryer costs on account of the moisture. This, to a certain extent, is compensated for in reduced repair cost to pulverising machinery, as lignite is easily ground. Some of the average operating costs, under recent conditions, are reported as follows :—

Small plants (2 tons to 5 tons per hour), 1·20 dols. per ton.

Medium plants (10 tons to 15 tons per hour), 75 cents per ton.

Large plants (20 tons and over per hour), 45 cents per ton.

We have prepared a table showing the approximate costs of plants of different capacities with certain costs as a basis :—

Estimated Costs of Pulverised Coal Plants.

Daily Capacity in Net Tons per 24 Hours.	No. of Mills Required.	Total Cost.	Building only.
		dols.	dols.
20	1—33-in.	34,000	5,500
50	1—42-in.	40,700	7,500
100	3—33-in.	49,500	10,700
200	3—42-in.	66,000	12,500
300	2—57-in.	79,200	14,750
400	3—57-in.	92,500	15,300
500	4—57-in.	106,700	16,000
750	5—57-in.	143,000	19,000
1,000	7—57-in.	177,000	21,750

These costs are for complete plants, but there should be added 10 per cent. for engineering. They are for January, 1919. The estimates are for construction in the eastern or middle regions of the United States. We also include the distribution of an estimate for a plant of 500 tons per day.

Coal Plant, Capacity 500 Net Tons per Day, 336 Tons Capacity in 16 Hours—Electrically Driven.

	dols.	dols.
Building, 32 ft. by 120 ft. erected.		
Structural steel	10,200	
Corrugated roofing	782	
Corrugated siding	1,400	
Louvres	648	
Steel windows and doors	1,650	
Concrete foundations	1,200	
Excavations	200	
		16,080
Machinery.		
Steel track, hoppers, grating, plate feeder, &c.	1,000	
Single-roll coal crusher	1,410	
Motor for coal crusher	683	
Steel cased elevators	4,266	
Motor drives for elevators	1,720	
Magnetic separator	708	
Storage bins and supports	2,600	
Crade feeder with driving mechanism	750	
Rotary coal dryer with exhauster, dust collector, piping and motor drive ..	12,670	
Brickwork for dryer	1,400	
Pulverised coal equipment for dryer ..	1,500	
Screw conveyor with trough	700	
Three 20-ton bins above mills, with discharge spouts, bin grates and spouts	4,571	

General.—The experiments described give a general outline of the work done by Garred and Cavers, and the authors have presented general information obtained to date. The experiments of the Tennessee Copper Company are continuing with encouraging results, and at the plant of the International Nickel Company, the most recent work has been to endeavour to operate the furnace entirely without coke, following earlier work where an average of about 50 per cent. of the coke had been replaced. The results, with all coke eliminated, have not as yet been satisfactory, but are sufficiently encouraging to continue the experimentation with that object in view.

The processes involving the application of pulverised fuel to blast furnaces have been patented in the United States, Canada and many foreign countries; the patentees, Garred and Cavers, both being engaged in work connected with the smelting of non-ferrous ores, and both were simultaneously working on practically the same problem, of the combustion of finely-divided fuel in a blast furnace. Owing to the magnitude of the problems involved, a consolidation of their interests was effected recently, by the formation of the Garred-Cavers Corporation, New York, which company has acquired the patents issued and pending in connection with this work. It is expected that experiments on the smelting of silver-lead ores will be commenced in the near future, and we have every reason to believe the prospects are good for increasing the efficiency of blast furnace practice.

During the last few years, some 20,000,000 tons to 30,000,000 tons of non-ferrous ores per year have been treated in blast furnaces in the United States, Canada and Mexico, and it is believed that further developments of a satisfactory nature in connection with this work will enable a large proportion of these ores to be smelted with considerable economies in fuel.

SALVAGE PLANT FOR SALE.—Attention is drawn in No. 13, *Surplus*, December 1st, the publication of the Disposal Board, Ministry of Munitions, to several sets of portable centrifugal salvage pumps from 4 ins. to 12 ins., both steam and oil engine-driven; also to a number of "submersible" salvage units with 4-in. and 6-in. pumps. Particulars as to the capacity of these sets, together with description, and information as to where the plant can be viewed, will be forwarded on application to the Controller, Plant and Machinery Section, Disposal Board, Charing Cross Buildings, London, W.C. 2.

50-TON HYDRAULIC METAL-TESTING PLANT.

Our figures on page 754 illustrate a 50-ton self-contained hydraulic plant designed for carrying out tensile, bending, transverse and compression tests on metal specimens. It is constructed by Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, of Manchester. The idea of the plant is the provision of a compact and comparatively portable self-contained unit which requires but simple foundations, and which can be used for all ordinary commercial mechanical testing of metals. The arrangement consists in essence of a vertical hydraulic testing machine, shown to the right in Fig. 1, together with an electrically-driven pump and an accumulator. The plant works with oil. The apparatus shown to the left in the figure is a second testing machine which has an inverted cylinder and is more particularly intended for carrying out bending tests. This machine may be looked upon as an extra, and as not forming part of the normal plant. As will be seen from Fig. 1, it is mounted on an independent bedplate. Outline views of the plant from two sides are given in Figs. 2 and 3.

The main testing machine is built up of a cast-iron frame carrying a fluid-pressed steel cylinder in which works a frictionless ram without leathers. The cylinder is bored and ground 3 to 4 ten-thousandths of an inch larger than the ram, and a little oil is allowed to leak and is led away by a pipe. Two steel rods attached to the ram carry a moving steel crosshead to which holders for tensile testing on screwed pieces, ¾ in., ½ in. and 1 in. diameter, may be attached. Outside fixed tension bars carrying a fixed crosshead are fitted, and are used for carrying the necessary apparatus for bending, transverse and compression tests. The method of setting-up for these various tests is shown in Figs. 4 to 6. Two Bourdon gauges are fitted to the machine; one for tests up to 50 tons total and a lighter one for transverse tests. They register the pressure obtained in tons per square inch on the test piece. A deadweight arrangement, which can be seen behind the machine in Fig. 1, is fitted for testing the accuracy of the gauges. Other details of the plant will be followed from the figures. The pump is double-acting and an automatic trip is fitted to control its starting or stopping from the position of the accumulator weight. The dimensions of the complete plant, exclusive of the special bending test machine, are length 12 ft., width 4 ft. 6 in., and height 12 ft. The fitting of the bending test machine naturally reduces the amount of setting-up required if a considerable variety of tests are undertaken, and enables the main machine to be arranged exclusively for tensile tests. It is stated that accurate tests can easily be carried out on the machine at the rate of one per minute. One operator can work the whole plant.

THE PHYSICAL SOCIETY OF LONDON.

At the meeting of the Physical Society of London, held on November 14, at the Imperial College of Science, Professor C. H. Lees, F.R.S., president, in the chair, a paper, entitled "*On the Self-Inductance of Single-Layer Flat Coils*," was read by Mr. S. Butterworth. The paper stated that two formulæ are established for the computation of the self-inductance of single-layer flat coils, one for the case when the inner and outer radii are not very different and the other for the case of small inner radius. The two formulæ are shown to be consistent and capable of including all possible cases. From the formula a table is calculated which enables the inductance to be expressed in the form $l = Q n^2 r^3$, in which n is the number of turns per centimetre, r the outer radius and Q is a tabulated function of the ratio of the inner and outer radii. Some applications of the table are given.

Discussion.—Dr. Eccles recalled the very useful paper published by the author some years ago, giving formulæ for thick coils. He had found these extremely useful, and felt sure that the results of the present paper would prove equally valuable. He felt that people hardly realised their indebtedness to those who undertook these very laborious calculations for the help of the users of coils.

Dr. E. H. Rayner pointed out how useful such formulæ were in the construction of inductances. Almost anyone could make up a resistance to have any desired value; but it was another matter with regard to inductances. With formulæ such as these, however, it was possible with the simplest appliances to construct an inductance to within 1 per cent. of the required value.

Professor G. W. O. Howe communicated the following: In the "Archiv für Elektrotcknik," vol. iii, 1915, page 187, is a paper by J. Spielrein, entitled "The Self-Induction of Air-Core Spirally-Wound Coils" (see "Science Abstracts," Elec. Eng., 1915, No. 660). Spielrein's final formula is $L = T^2 r_2 f(r_1/r_2)$, where T is the total number of turns, whereas Mr. Butterworth's formula is $L = n^2 r Q$, where n is the turns per centimetre. Since $T = n(r_2 - r_1)$ Spielrein's formula can be written $L = n^2(r_2 - r_1)^2 r_2 f(r_1/r_2)$. Hence: $Q = (r_2 - r_1/r_2)^2 f(r_1/r_2) = (1 - r_1/r_2)^2 f(r_1/r_2)$.

Now Spielrein gives a table of $f(r_1/r_2)$ to seven places for all values of r_1/r_2 from 0 to 1 by steps of 0·01. Comparing Spielrein's $f(r_1/r_2)$ with Mr. Butterworth's Q we have:—

r_1/r_2.	$f(r_1/r_2)$.	$(1-r_1/r_2)^2 f(r_1/r_2)$.	Q.
0·0	6·969573	6·969573	6·970
0·5	18·97400	4·74350	4·743
0·9	45·74241	0·4574241	0·4574
1·0	∞	0 × ∞	0

It seems obvious that Mr. Butterworth was unaware of this paper.

The author, in reply, said he had not known that Spielrein had tackled the problem. He was afraid it rendered his paper somewhat unnecessary.

Dr. Eccles pointed out that it was of great importance that two independent investigators obtained results in such striking agreement.

A paper entitled "*An Experimental Method of Determining the Primary Current at Break in a Magneto*," was read by Dr. N. W. McLachlan. In this paper a method of obtaining experimentally the current at break in a magneto is described. A condenser is connected across the secondary winding to reduce the voltage below that required to cause sparking at the safety gap. The peak voltage due solely to interruption of the current at any speed is found. The interrupted direct current necessary to give the same peak voltage is also found by using a calibrating circuit. The magnitude of this current is equal to that broken in the magneto. The influence of the secondary condenser on the primary current at high speeds is discussed.

Discussion.—Dr. Norman Campbell (communicated the following): It is quite possible to make satisfactory measurements on the primary current of a magneto by inserting in the circuit a small non-inductive resistance and taking the potential difference across it by means of a rotating "contactor." The total resistance inserted need only be 0·03 ohm; 0·01 for the leads and 0·02 for the measuring resistance. By the use of a suitable potentiometer method a change of 0·02 ampere can then be detected, which is ample for practical purposes. It was found that on increasing the total resistance inserted to 0·11 ohm, the current did not change by as much as 3 per cent.; accordingly the disturbance caused by the resistance of 0·03 ohm must be quite inappreciable.

With this arrangement it is possible to test the accuracy of Dr. McLachlan's method by examining whether the secondary peak potential is proportional to the primary current. It was found that it was very accurately proportional when the current was changed by varying the strength of the magnets. By changing that strength within wide limits it seems possible to change all currents and potentials in the circuits without changing appreciably their ratio or wave form.

On the other hand, considerable discrepancies, amounting sometimes to 10 per cent., were found when the secondary peak potential produced by breaking a primary current generated by rotation of the armature was compared with that produced by breaking the same current supplied by a battery. His experience indicated that errors of this order might occur in using Dr. McLachlan's method (allowance, of course, was made for the E.M.F. generated directly in the secondary by rotation of the armature).

For the rest, his experiments agreed in general with those of Dr. McLachlan. Since he had not kept the records he could not discuss them in detail; but he remembered being surprised how different was the open-circuit voltage wave from that shown in Fig. 2.

Dr. Eccles said that Dr. McLachlan had used an indirect method and then made a series of check experiments to show that the various errors introduced are negligible. Dr. Campbell had mentioned a direct method. He thought that direct methods were preferable where possible; and suggested that the Dufour cathode ray oscillograph would have been the ideal instrument for the investigation of the magneto.

Dr. Rayner said there was one point about which he felt doubtful. This was on page 2 about 10 lines down. The calibrating flux was not employed in the same way as the working flux, one being reversed and the other not. He thought some method might be devised to avoid this discrepancy. He was afraid the power required to work the Dufour oscillograph might be greater than was readily obtained from a magneto.

Dr. Eccles: An amplifier could be used.

Professor Lees pointed out that the important thing in these researches was that we were obtaining knowledge about the magneto, which had hitherto been treated almost wholly on empirical lines.

The author, in reply, stated that he had tried the method outlined by Dr. Campbell, but without the use of a rotating contactor. The results were unsatisfactory owing to the effect of transients before and after break. In order to eliminate these, it was essential that the contactor circuit should be broken before the primary. This, however, did not eliminate transients before break. The effect of these will be evident from the remarks in the paper, on the auxiliary coil method. Unless the interval between the breaking of the two circuits is small, errors can easily arise. Dr. Campbell's statement regarding resistance only applies at high speeds of say, 700 r.p.m. or more. At low speeds, owing to the small value of the primary inductance reactance, the current is nearly proportional to the resistance.

If the method of measuring the voltage drop across the resistance to one which gives the peak value, the current at break is measured only when the maximum value does not occur before break. If the maximum occurs before break, as it does at retard, the peak voltage across the resistance is not a measure of the current at break, although the values so obtained may be proportional to the secondary voltage of the magneto found by altering the strength of the magnet. The question arises as to whether the peak voltage—due solely to interruption of the current, as found by Dr. Campbell's method, is proportional to the current broken when the speed is varied.

There are several ways in which discrepancies may arise in measuring the peak voltage by breaking a direct current in a magneto: (1) If the direction of the current is different from that during rotation, errors of the order mentioned by Dr. Campbell may occur. This can be tested by moving the armature through 180 electrical degrees and repeating the experiments. (2) The position of the armature at break must be found fairly accurately, since the polarisation of the core due to the magnet varies with the armature position. Polarisation affects the primary and secondary effective resistances and inductances, also the flux change due to a given current. These react on the peak voltage. (3) The peak voltage found by breaking a direct current (flowing in the proper direction) at advance or retard is not the same for all armature positions. This is probably due to some asymmetry. (4) The rectifying valve should pass no reverse current, and at low armature speeds the leakage should be extremely small. (5) Great care must be taken to prevent sparking at the separate contact breaker used for calibration. If sparking or rather arcing occur there are variations in the peak voltage, and the battery and rheostat part of the oscillatory circuit.

Unfortunately, Dr. Campbell does not state (*a*) the type of magneto, (*b*) the values of the currents, (*c*) the speeds, (*d*) the position of the timing lever, (*e*) whether the 10 per cent. error was in excess or defect. In practice one is generally concerned with currents of 2 amperes or more, and there does not seem to be any definite reason why the method given in the paper should be subject to errors of 10 per cent. in measuring currents of this magnitude if the precautions outlined above are taken. Dr. Eccles' suggestion to use the Dufour oscillograph for measurements on the magneto, was contemplated eight months ago. Up to the present, however, it has not been possible to secure one of these instruments. Without oscillograms of the voltage wave form obtained by apparatus of this nature, it is impossible to know precisely what happens in the secondary of a magneto after break. With regard to Dr Eccles' reference to the use of an amplifier to measure the primary current, difficulties may arise due to transients which would influence the valve circuits. Owing to the fact that the magneto radiates oscillations of very short wave length (10 m. to 30 m.), a further source of trouble with the amplifier might arise. This, however, is a matter for experiment.

The point raised by Dr. Rayner and mentioned in the paper should not have serious consequences for currents of 2 amperes or more. In view of the fact that an appreciable variation exists between the performances of magnetos of the same type, it is not necessary to measure the current more accurately than 5 per cent. This will be clear when one remembers that only about 30 per cent. of the primary electromagnetic energy in the form $\frac{1}{2} L I^2$ is transformed into electrostatic energy in the secondary. The chief object in the determination of the primary current was to obtain an estimate of the value of $\frac{1}{2} L I^2$.

A new form of Wehnelt Interrupter was exhibited by Mr. Newman. The Wehnelt interrupter is not used generally owing to the rapid disintegration of the platinum wire, and also because the current required for the working of the cell is large. If, however, a modified form is adopted these disadvantages disappear. A plate of aluminium, area 50 sq. cm., takes the place of the lead plate, the other electrode being platinum wire sealed in a glass tube. These electrodes are immersed in a saturated solution of ammonium phosphate made alkaline with ammonia. This interrupter works equally well with direct or alternating currents. In the former case the wire must be made the positive electrode, while with alternating currents the passage of the current is such that the wire is positive to the aluminium. The cell works with a minimum potential difference of 18 volts, but the frequency of the interruptions increases with the applied potential difference.

Captain C. E. S. Phillips said it was important that the experiments should be repeated on the scale required for ordinary X-ray work. He would be glad to afford the author any facilities he required for this purpose. Had he tried the use of potassium carbonate instead of ammonium phosphate? In the X-ray service in the Army a reliable portable interrupter was badly required. The objection to the ordinary Wehnelt was that a voltage of 80 to 100 was required.

Mr. W. R. Cooper asked if rectification was essential to the working of the instrument. Would plates of other metals than aluminium work?

Mr. Newman said he had not tried other salts. Any metal would serve, but aluminium was best and required the least voltage.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—The developments of the past fortnight make it quite clear that only the moulders' strike and railway delays are holding up a big trade expansion in engineering products, steel and tools. Inquiries, which have been on the increase for the last three months, are more numerous to-day than since the armistice. Owing to labour uncertainty and the difficulties of getting away output, manufacturers are loath to commit themselves to short-dated contracts. But there is a marked increase in the amount of business booked for delivery over the next twelve months. An early settlement of the moulders' strike would give a healthy impetus to the South Yorkshire engineering trades, and would also put steelmakers in a better position

to cope with the increasing demands made upon their output by home and foreign producers. The pressure of work at the rolling mills is one of the healthiest features of the current trade position. Orders tend to increase rather than to diminish. To make the best of the opportunity revision of working arrangements, previously reported in these notes, is being extended to embrace a larger number of firms. For instance, Messrs. John Brown and Co., Limited, have decided to reopen an auxiliary rolling mill which has not been in operation since the slump in armament work. Forges are sharing in the new prosperity, and there is no doubt that foundries would also be employed on full-time working but for the disastrous effects of the moulders' dispute. Several extensions to rolling plant are contemplated, and engineers with whom the contracts for the new machinery have been placed are being pressed for delivery. Open-hearth steel is a very active section. The local output is absorbed on day-to-day contracts. Shippers could handle a much bigger tonnage for despatch to allied buyers, if it were available. The output of crucible steel has been increased to meet a decided expansion in the demand, but more orders are needed to keep the furnaces running full time. High-speed steel is not an active section. New business is still held up by the existence at many of the leading works of stocks purchased during the war.

South Yorkshire Coal Trade.—The experiment of holding the meeting of the Sheffield Coal Exchange on Wednesdays has not been successful, and the promoters have decided to revert to the former practice of holding the meeting on Fridays. A good deal of unsettlement still prevails as a result of the Government's new coal policy. Following the announcement of a prospective reduction of 10*s.* per ton in the price of house coal, merchants experienced wholesale cancellation of orders. Since the new price came into operation, demands have shown a corresponding increase, and merchants are not at all sure of their ability to meet all winter commitments unless the output at the pits is maintained. The trade is much agitated by the question as to what, under the new Order, is to be regarded as house coal as distinct from manufacturing fuel. The mixture of the two qualities has caused the distinction to be ruled, during the past two or three months, by the ultimate destination of the fuel. A very active demand continues for all classes of steam coal. Local manufacturing concerns and inland works are well supplied, though it is impossible at the current rate of output materially to augment reserve stocks. Quotations:—Best branch handpicked, 33*s.* to 34*s.*; Barnsley best silkstone, 33*s.* to 33*s.* 6*d.*; Derbyshire best brights, 31*s.* to 32*s.*; Derbyshire house coal, 18*s.* to 19*s.*; Derbyshire best large nuts, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire small nuts, 27*s.* 6*d.* to 28*s.* 6*d.*; Yorkshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire hards, 28*s.* 6*d.* to 29*s.* 6*d.*; best slacks, 24*s.* to 25*s.*; nutty, 23*s.* to 24*s.*; smalls, 19*s.* to 20*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Coal Markets.—A decided change has occurred in the position of the coal market. A week ago buyers experienced no difficulty in securing supplies of practically any grade of coal on the basis of 70*s.* for the better quality large steams and 55*s.* for best steam smalls. To-day actual business is restricted and supplies almost unobtainable. This is due to the fact that a large quantity of shipping has arrived at the local docks during the past week, and collieries, who generally are fully stemmed on paper up to Christmas, have sufficient tonnage to hand to keep them going. Inadequate transport facilities are, however, handicapping the free export of coal, and cases are known where collieries have been obliged to effect temporary pit stoppages through a lack of empty wagons, despite the fact that there may be as many as a dozen vessels actually in dock waiting for cargoes. In these circumstances it is here and there possible for buyers with boats ready under the tips to secure odd parcels at from 10*s.* to 15*s.* per ton below the price asked for shipment even a few days ahead. Collieries are now indicating up to 90*s.* for the best large steam coals and 70*s.* for best small steams, and these figures have been paid, whereas a week ago it was possible to secure similar coals at 80*s.* and 55*s.* respectively. In many instances collieries are so fully booked with orders that they are refusing to give quotations for delivery over this month. Patent fuel is also fully sold, and prices are nominally from 80*s.* to 85*s.* Coke is scarce on the basis of 107*s.* 6*d.*, and pitwood also is scarce and commands 65*s.*, compared with 55*s.* a week ago. Exports of coal from South Wales last week amounted to 331,329 tons, of which 188,294 tons were sent from Cardiff, 67,616 tons from Newport, 37,391 tons from Swansea, and 38,028 tons from Port Talbot.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is continued good home and foreign inquiry for Cleveland pig-iron, but actual transactions are on only very limited scale. Producers show marked disinclination to commit themselves beyond the end of the year. The anticipated advance in railway rates is expected to come into operation in January, but as provision is made, in contracts, for such an event, the probability of the change should not check forward business. Truck shortage continues very seriously to hamper distribution, and scarcity of tonnage is interfering with exports. Foundry pig-iron is still difficult to obtain, although the scarcity is less pronounced than it has been, due to local ironfounders having laid in large stocks during their enforced idleness through the strike, and no longer demanding supplies. Continued abundance of forge pig-iron has no apparent weakening influence on that quality. For home consumption, No. 1 is 167*s.* 6*d.*, and No. 3 g.m.b., No. 4 foundry and No. 4 forge are all quoted 160*s.*; and for export, rates are 5*s.* above the foregoing quotations.

Hematite Iron.—Demand for East Coast hematite iron is quiet, and supply is very ample, but values are upheld. No. 1 is 202*s.* 6*d.* for home use, and 207*s.* 6*d.* for shipment to foreign ports; and mixed Nos. are 200*s.* for home purposes, and 205*s.* for export.

Manufactured Iron and Steel.—Producers of manufactured iron and steel are so well booked up that they are indifferent to new business. A restart has been made at the Britannia rolling mills after a week's stoppage through the truck shortage, but nearly all the works have from time to time partially to suspend operations because of the non-arrival of wagons, and this week the Consett rolling mills are entirely closed. Export quotations are a little above the following, which govern the home trade:—Common iron bars, 22*l.*; marked bars, 25*l.*; block sheets, 28*l.* to 29*l.*; galvanised sheets, 36*l.*; steel ship, bridge and tank plates, 18*l.* 5*s.*; steel boiler plates, 21*l.* 10*s.*; steel angles, 17*l.* 15*s.*; steel joists, 17*l.* 10*s.*; and heavy sections of steel rails, 16*l.* 10*s.*

Iron and Steel Shipments.—A substantial improvement is recorded in the official returns of iron and steel exports from the port of Middlesbrough during October, the grand total being 47,783 tons, as compared with 39,948 tons in October, an increase of 7,835 tons.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—Little change falls to be recorded in the steel industry of Scotland, and active conditions are general. The recent advance of 1*l.* per ton in current prices does not seem to have had any effect on the demand, which is as pressing as ever, and deliveries go rapidly into consumption. Fresh bookings are very satisfactory, and there is a very considerable amount of work on hand, so that a long, steady run is assured. Black-sheet makers continue to be actively employed, and the demand for the heavier gauges is very pressing both for home use and for export. Galvanised sheets, despite their present high value are the subject of very good business.

Scotch Pig-Iron Trade.—The Scotch pig-iron trade continues to maintain a strong position, and the general demand is good. Deliveries are fairly satisfactory, but some improvement in the matter of railway wagons would be very beneficial. The demand for hematite from steel makers is now much better and very respectable quantities are being delivered. Export business is improving, and may soon amount to a considerable tonnage.

Scotch Shipbuilding.—The output for November from the various Scotch centres was as follows:—

	Vessels.	Tons.
The Clyde	28	53,257
The Forth	3	6,830
The Tay	1	2,500
The Dee	3	315
Total	35	62,902

The Clyde total is the fourth highest monthly output for the year to date, but is 32,517 tons under the best month, which was April, when the figures were 34 vessels of 85,774 tons. The figures for the eleven months are:—

	Vessels.	Tons.
The Clyde	255	507,363
The Forth	20	47,738
The Tay	12	17,890
The Dee	43	9,510
Total	339	582,501

Wages in the Iron Trade Advanced.—Mr. John M. MacLeod, C.A., has certified that the average net selling price for September and October, 1919, is brought out at 21*l.* 19*s.* 8·29*d.* per ton. This means an increase in the wages of workmen of 7½ per cent. on basis rates. The manufactured iron trade scale is now 154 per cent. above basis rates.

Blast furnacemen's Wages Advanced.—As from the first pay in November, the wages of the blast furnacemen are to be advanced by 15 per cent. on the basis rates (with a minimum of 6*d.*), and the usual proportionate increase will be given to boys and women. The scale in this trade is now 177·5 per cent. above basis.

Iron and Steel Workers' Wages Increased.—The steel and iron workers have been successful in getting the award of November 5, of 5*s.* per week, extended to the rivet, nut and bolt workers, tube trade, and their members in the cement trade. Negotiations are proceeding for making the advance applicable to the mill employees. The steel employers have already agreed on the joint application of the Iron and Steel Workers' and the Iron and Steel Trades' Confederation to the extension of the award to the men not on the sliding scale.

"THE EDGAR ALLEN NEWS."—The third issue of this publication contains several articles dealing with Messrs. Edgar Allen and Co.'s specialities, with the hardening of steel, and pointing out the difference between acid and basic steel, the advantages of manganese steel for permanent ways, &c., all of which form very interesting reading.

NOTICES OF MEETINGS.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, December 6, at 3 p.m., a General Meeting, in the Royal Technical College, George-street, Glasgow. Business: The Minutes of the last General Meeting will be read; new Members will be elected; Mr. H. M. Cadell's paper on "Oil Possibilities in Scotland" will be discussed; Messrs. William Hill and J. A. Cook's paper on "Fuel Economy in the Production of Power at the Apedale Works of the Midland Coal, Coke and Iron Company, Limited, Apedale, Newcastle, Staffordshire," will be discussed. The discussion will be opened by Mr. R. W. Dron.

THE BRADFORD ENGINEERING SOCIETY.—Monday, December 8, at 7·45 p.m., in the Hall of the Bradford Technical College, when a lecture will be given by Mr. H. Major, Assoc.M.Inst.C.E., on "Reinforced Concrete Construction for Warehouses and Factories."

THE ROYAL SOCIETY OF ARTS.—Monday, December 8, at 8 p.m.: Cantor Lecture, "Synthetic Drugs," by Mr. John Theodore Hewitt, M.A., D.Sc., F.R.S., Emeritus Professor of Chemistry, East London College, University of London (Lecture II). Tuesday, December 9, at 4.30 p.m.: Colonial Section: "Problems of the West Indies," by Sir Edward Davson, President of the Associated West Indian Chambers of Commerce. Lieutenant-Colonel L. S. Amery, M.P., Under-Secretary of State for the Colonies, will preside. Wednesday, December 10, at 4.30 p.m.: "Trueman Wood" Lecture, "Some Possible Sources of Energy," by Sir Oliver Lodge, D.Sc. Sc.D., LL.D., F.R.S. The Hon. Sir Charles Algernon Parsons, K.C.B., M.A., D.Sc., D.Eng., F.R.S., Vice-President of the Society, will preside.

THE CERAMIC SOCIETY.—Monday, December 8, at 7.30 p.m., Meeting in the Central School of Science and Technology, when a paper will be read entitled "Fine Grinding of Potters' Materials" (Part II), by Mr. L. G. Hill. Dealing in particular with the influence of the shape of the particle, and being a supplementary paper to that read by the same author in November, 1914.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 9, at 5.30 p.m., discussion on the lecture which was delivered by Mr. Henry Herman Gordon, B.A., Assoc.M.Inst.C.E., on November 25, on "Some Aspects of Metropolitan Road and Rail Transit," will be continued.

THE JUNIOR INSTITUTION OF ENGINEERS, NORTH-EASTERN SECTION.—Tuesday, December 9, at 7.15 p.m., in the Engineering Lecture Theatre of Armstrong College, Newcastle-on-Tyne. A paper will be read on "Notes on Design and Construction of Polyphase Induction Motors," by Mr. S. H. Moore.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, December 10, at 7.30 p.m. Paper by Mr. A. Ramsay, on "Industrial Reconstruction." Mr. H. S. Hele-Shaw, D.Sc., LL.D., F.R.S., in the chair.

THE ROYAL AERONAUTICAL SOCIETY.—Wednesday, December 10, at 8 p.m., Meeting in the Theatre of the Royal Society of Arts, John-street, Adelphi, London, W.C. Mr. J. D. North will give a lecture on "Aircraft Undercarriages." The chair will be taken by Lieutenant-Colonel Mervyn O'Gorman, C.B., R.A.F.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 11, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. "Scientific Management," a solution of the "Capital and Labour" problem, by Captain J. M. Scott Maxwell.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, December 12, at 7.30 p.m., at 39, Victoria-street, S.W. 1. "A Walk through the Shops at Richborough," by Mr. R. S. Kirlew.

BRITISH COAL OUTPUT.—The coal output for the week ending November 8 was 4,804,456 tons, as compared with 4,674,532 tons for the week ending November 1, and 4,812,595 tons for that ending May 31.

"THE STUDY OF FLOTATION."—ERRATUM.—Mr. H. Livingstone Sulman directs our attention to an error in the review of his paper upon "The Study of Flotation" (page 723 *ante*). It was stated that the process now deals with more than 500,000 tons of ores every year. The figure exceeds 60,000,000 tons per annum, or well over 1,000,000 tons per week. The figures given in the paper for the surface tension of fused metals are, Mr. Sulman adds, those determined by Dr. Sydney W. Smith, A.R.S.M., and published in his paper on "The Surface Tension and Cohesion of Metals and Alloys," read before the Institute of Metals on March 21, 1917.

SOUTH AFRICAN MINERAL OUTPUT.—The mineral output of the Union for August, says *The South African Mining and Engineering Journal*, was valued at 4,255,181*l.*, a decrease of 189,894*l.* on the July return. The diamond output was 199,037 carats, value 928,346*l.*, a decrease of 22,081 carats and 46,290*l.* in value. The coal output was 824,596 tons, value 265,605*l.*, being a decrease compared with July of 188,885 tons, and 15,562*l.* in value. The Transvaal produced 544,930 tons, an increase of 30,175 tons; Natal 396,084 tons, a decrease of 45,486 tons; Free State 71,205 tons, a decrease of 3,482 tons; and the Cape 387 tons, a decrease of 32 tons. The sales and shipments of tin were 189 tons from the Transvaal and 3 tons from the Cape. The labour returns show that 36,095 whites were engaged on mining, an increase of 1,606, and this is the highest number of whites recorded for the past few years as being employed in mining. The number of natives at work was 259,634, a decrease of 2,303 on the July figures.

50-TON HYDRAULIC METAL-TESTING PLANT.

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, ENGINEERS, MANCHESTER.

(*For Description, see Page* 752.)

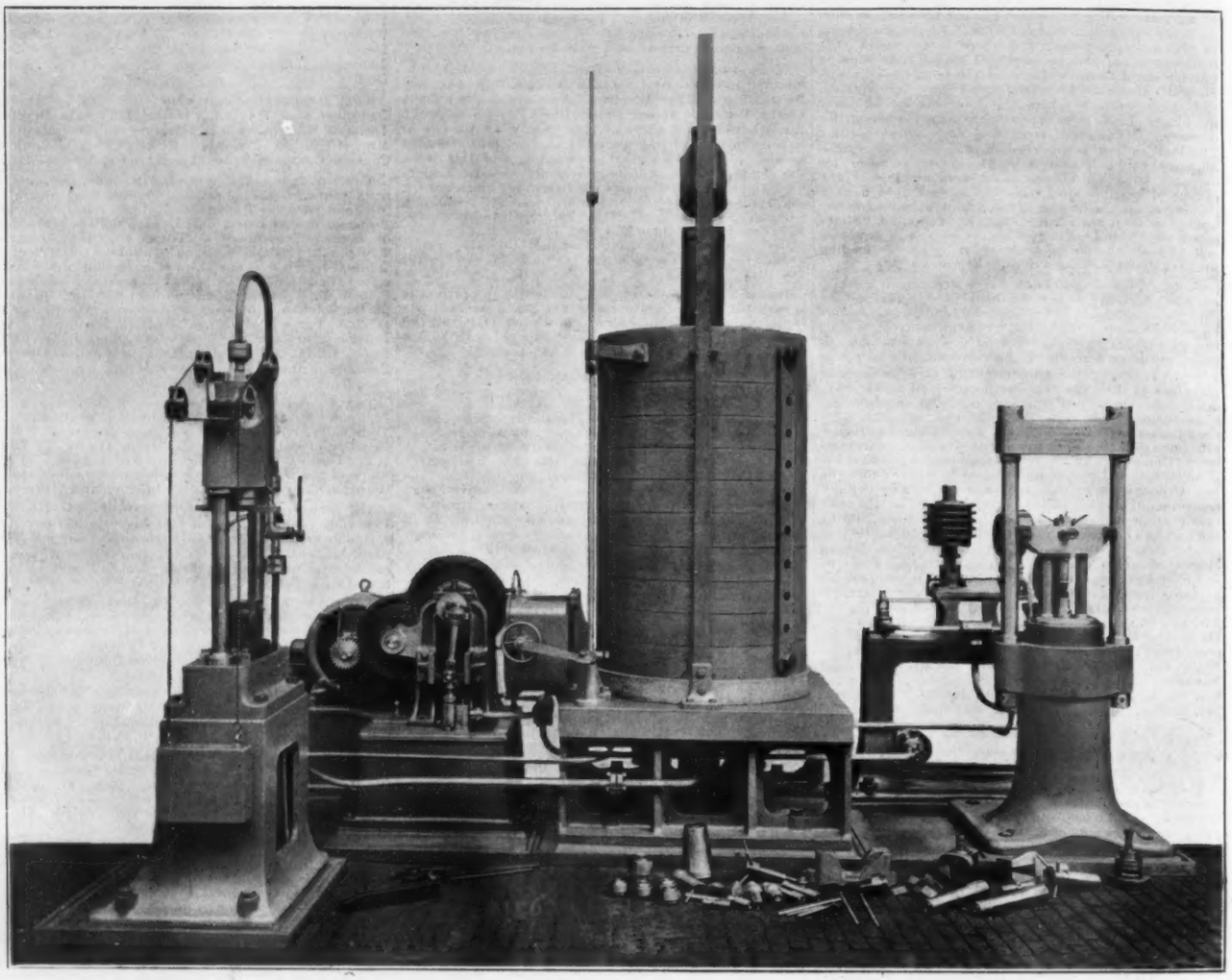
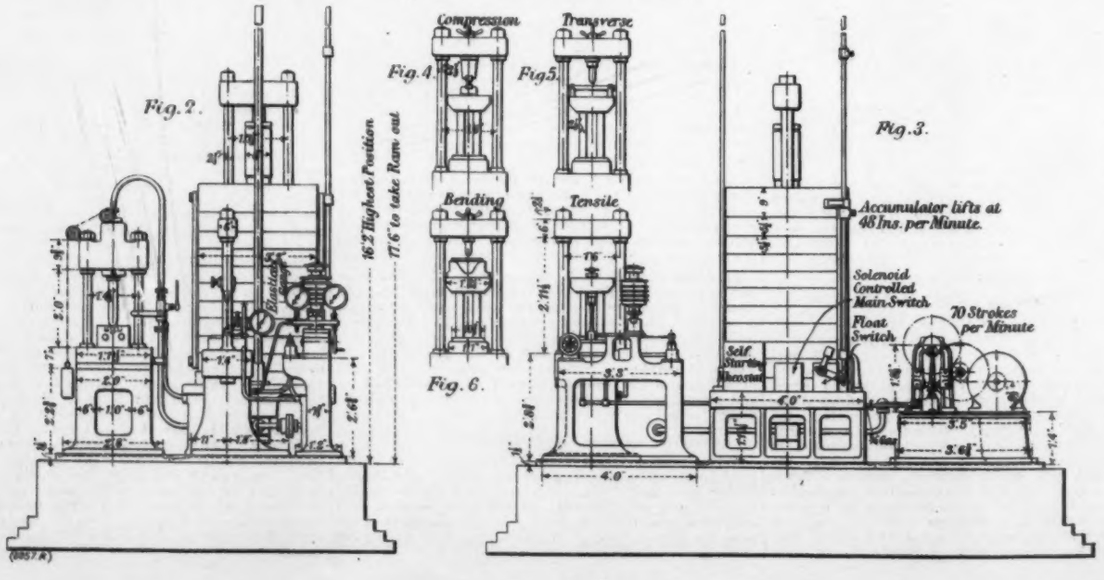


Fig. 1. General View of Plant.



UNITED STATES NAVY PATROL BOATS OF THE "EAGLE" CLASS.

(*For Description, see Page 742*)

Fig. 1. OUTBOARD PROFILE

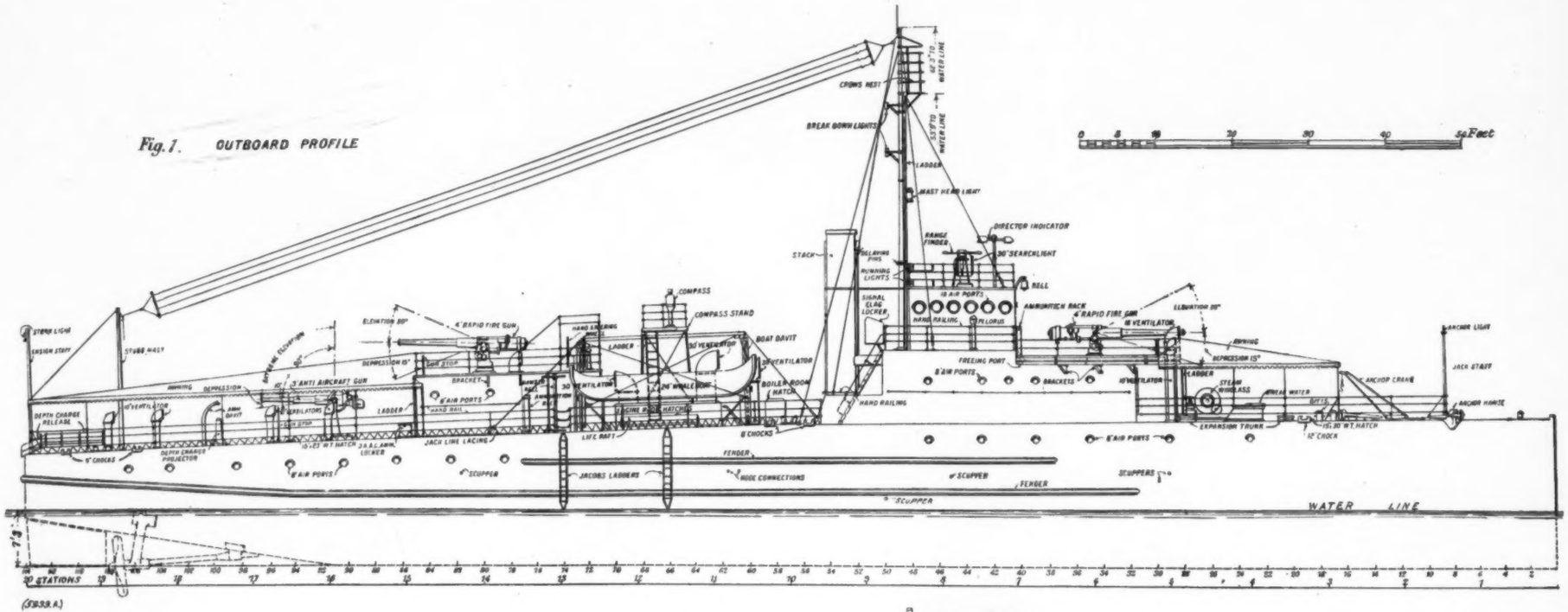


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Fig. 2. INBOARD PROFILE

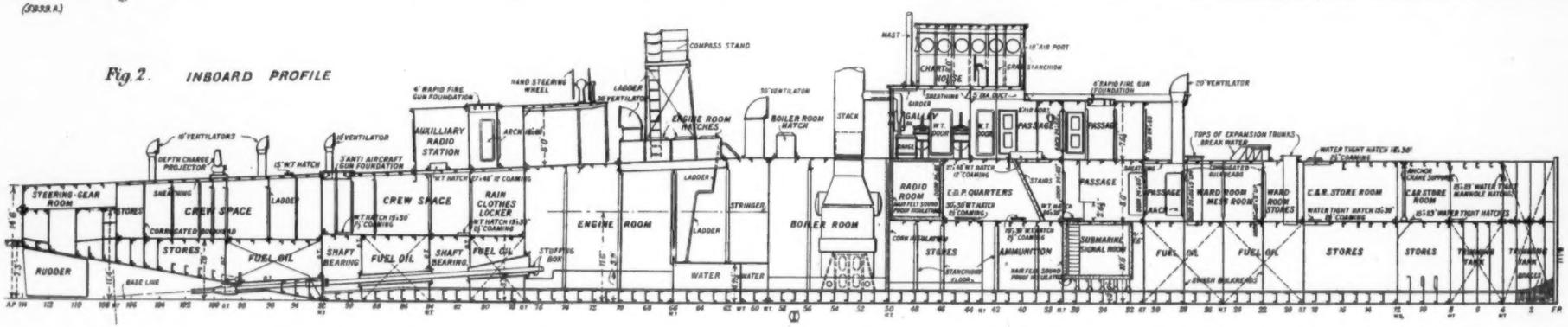


Fig. 3. GUN PLATFORM ON ROOF OF AFTER DECK HOUSE.

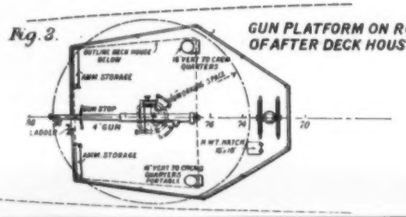


Fig. 4. ROOF OF CHART HOUSE.

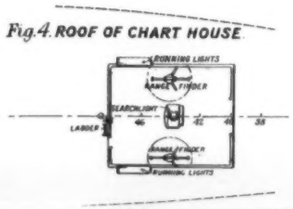


Fig. 5. BRIDGE CHART HOUSE & GUN PLATFORM.

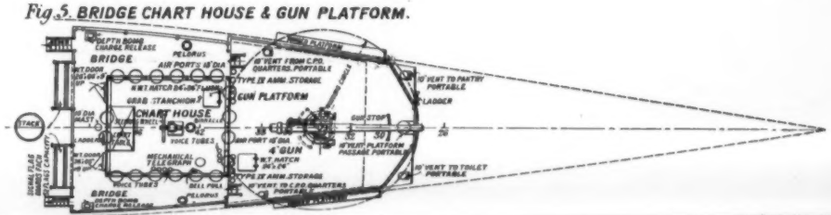


Fig. 6. MAIN DECK.

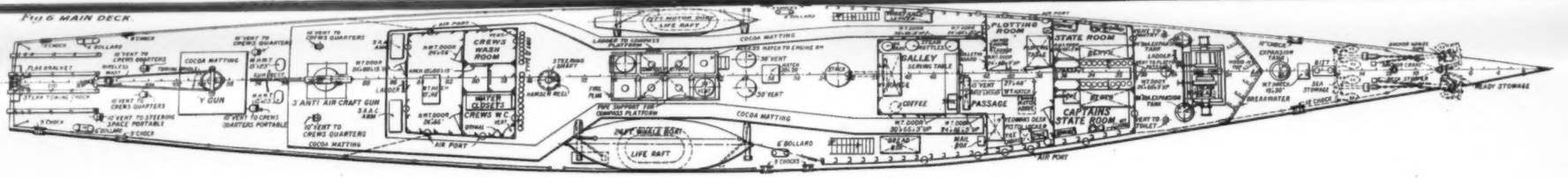


Fig. 7. PLATFORM DECK

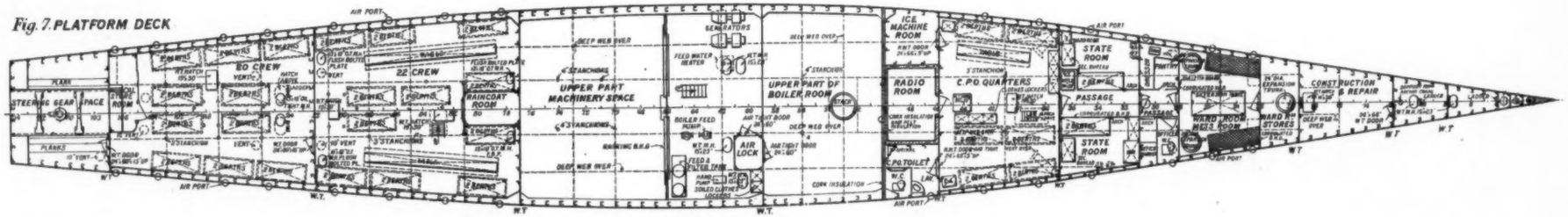


Fig. 8. HOLD.

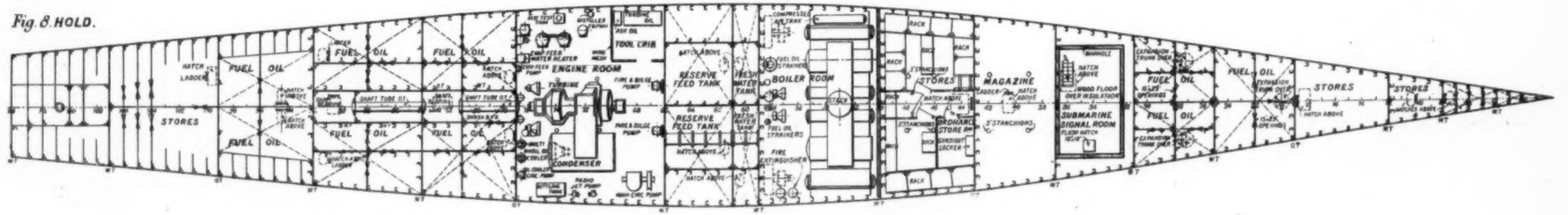


Fig. 9.
FRAME 26

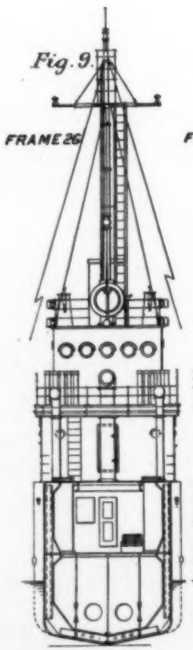


Fig. 10.
FRAME 34

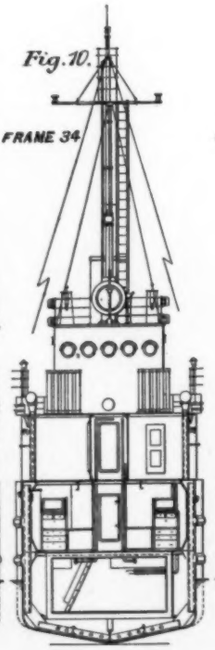


Fig. 11.
FRAME 44

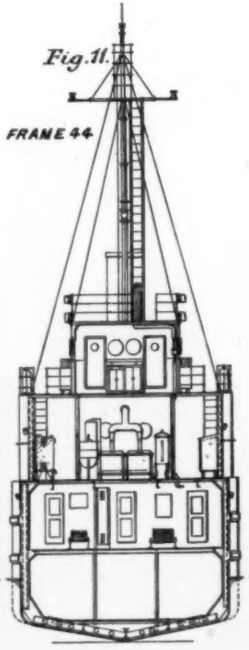


Fig. 12.
FRAME 58

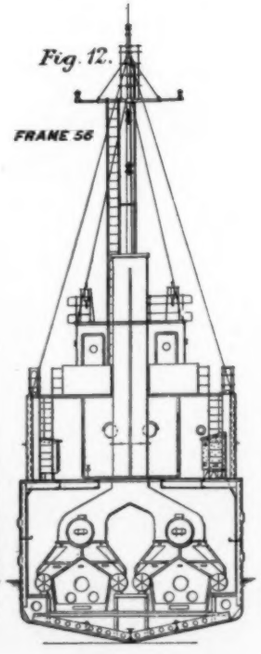


Fig. 13
FRAME 58

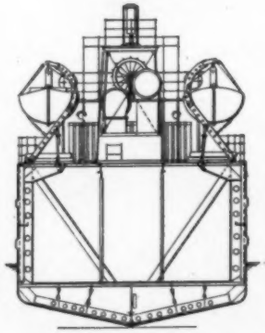


Fig. 14. FRAME 74

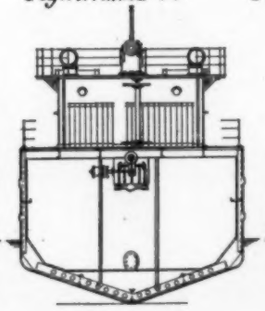
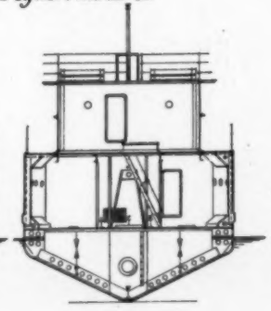


Fig. 15. FRAME 82



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UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue.
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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

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REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3 3 0
For Canada—	
Thin paper copies	£2 16 6
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For all other places abroad—	
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When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C. 2.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.

TELEPHONE NUMBERS—3863 and 8598 GERRARD.

CONTENTS.

	PAGE
Roads and Transport Congress and Exhibition	739
Mass Production and Inspection	742
U.S. Patrol Boats of the "Eagle" Class (*Illus.*)	742
15.9 Four-Cylinder Motor Car (*Illus.*)	745
The Alignment of Crankshafts	747
Industrial Notes	747
The Diesel Engine Users' Association	748
The Non-Ferrous Mining Committee	748
Application of Pulverised Coal in Blast Furnaces (*Illus.*)	749
"Use of Optical Pyrometers for Control of Optical Glass Furnaces"	749
"The Brinell and Scratch Test of Hardness"	749
50-Ton Hydraulic Testing Plant (*Illus.*)	752
The Physical Society of London	752
Notes from South Yorkshire	752
Notes from Cleveland and the Northern Counties	753
Notes from the North	753
Notes from the South-West	753
Notices of Meetings	753
The Mechanism of Lubrication	755
Direct Action	756
Engineering Schemes in Parliament	757
Lubrication	758
Notes	760
Literature	760
Books Received	761
Diagrams of Three Months' Fluctuations in the Prices of Metals	762
A Test of Watertight Bulkheads for Ship Subdivision (*Illus.*)	762
The Present Position of Mechanical Road Traction (*Illus.*)	764
Heavy Motor Transport and Road Construction	768

With a Two-Page Plate of the UNITED STATES NAVY PATROL BOATS OF THE "EAGLE" CLASS.

NOTICE.

Owing to the enormous increases in the cost of paper, engravings, and printing charges generally, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 9d. to 1s. per copy. This increase will date from and include the issue of Friday, January 2, 1920. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

CHRISTMAS HOLIDAYS.

Owing to Christmas Day this year, falling on Thursday, it is necessary that our issue of the 26th inst. should be published on Wednesday, the 24th inst., and, in consequence, all alterations to standing advertisements should be received not later than Wednesday, the 17th inst. Advertisements to appear classified under the various headings such as "Tenders," "Appointments Open," "For Sale," &c., must be received by the first post on Monday, the 22nd inst.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 753.

ENGINEERING.

FRIDAY, DECEMBER 5, 1919.

THE MECHANISM OF LUBRICATION.

IT has long been known that under favourable conditions any and every fluid may act as an effective lubricant. Thus molasses have been successfully used for lubricating sugar machinery, water is almost universally employed for lubricating the stern tubes of steamers, and Kingsbury showed, many years ago, that even a gas such as air is no exception to this general rule. Indeed, we understand that Mr. Ferranti, with characteristic boldness, investigated the possibility of using air as the sole lubricant for the spindles of cotton-spinning machinery, and that some success was achieved. At the same time, whilst under favourable conditions, as stated any fluid forms a satisfactory lubricant, it is of course a commonplace that only a small class of bodies are commonly recognised as lubricants. Under favourable conditions almost the sole physical property of importance in a lubricant is its viscosity; but as every one knows, when the conditions are such that the supply of lubricant is scanty or intermittent the relative viscosity of two liquids forms no criterion whatever as to their relative merits.

Engineers and chemists have long been attempting to correlate the value of a lubricant with its physical properties, but until recently with but little success. Indeed, the only satisfactory test of a lubricant lay in actual trial, and this involved the risk of scored or seized bearings should the lubricant prove unsuitable, and, moreover, the experiment might take a long time. In fact, for rapid results tests should be made with absolutely clean bearings, as otherwise the full effects of a change of lubricant may be slow in developing. The problem at issue naturally engaged the special attention of the Lubrication Committee, and as the full account of their investigations will not be available till the publication of their report, some information as to what has been accomplished was given by Dr. Stanton at the recent meeting of the British Association, at Bournemouth, and more by Mr. R. M. Deeley, in his paper read before the Physical Society on Friday last, at a meeting with which we have dealt on another page.

At the outset of the inquiry it was noted that the physical properties of lubricants were commonly tested at atmospheric temperature and pressure. In any imperfectly lubricating bearing, however, the load is concentrated on a very small active area, and the pressure in the oil film in such regions will therefore be exceedingly high. It appeared possible accordingly that this apparent lack of any connection between the physical properties of an oil and its value as a lubricant might disappear if these physical properties were determined with the oil subjected to a high pressure instead of to atmospheric pressure only. In particular it was known that the viscosity of certain liquids was greatly increased at high pressures, and it seemed worth while to ascertain whether this was the case with lubricating oils. The full particulars of the tests made will no doubt be given in the final report of the Lubrication Committee, but as stated by Dr. Stanton, on Friday, the general result was to show that there was a very large increase of viscosity with pressure. For vegetable and animal oils it was about fourfold as great under a pressure of 9,000 atmospheres as at 1 atmosphere, whilst with mineral oils it was 16 times as great. Hence it would seem that the viscosity of mineral oils increases much more rapidly with pressure than does that of the organic oils. Had it been the other way round, it would have been possible to frame an explanation of the greater lubricating value of vegetable oils on this change of viscosity with pressure.

Some other factor must, from the foregoing results, be responsible for the quality known, for want of a better term, as "oiliness." The solution seems to have been found by Mr. R. M. Deeley, who many months ago reported to the Lubrication Committee that he had found that good lubricants adhered much more strongly to metallic surfaces than did indifferent lubricants.

In his view a good lubricant forms a sort of quasi-chemical combination with metallic surfaces, and is with very great difficulty dislodged therefrom. In fact, to remove the oily film thus formed it is necessary to grind away the surface under water, it being impossible to wipe it clean and very difficult, perhaps impracticable, to dissolve it off. This observation, it may be noted, throws light on the well-known fact that a prolonged test is required to establish the effect of a change in the lubricant used in a mill. Indeed, it was further found that the addition of a small quantity of a vegetable oil to a mineral lubricant had often quite a disproportionate effect in enhancing the oiliness of the latter.

Mr. Deeley used, in his experiments, a very simple machine, which we describe in our report of the meeting of the Physical Society last Friday. The machine measures the static friction between a tripod and a plate below it. On rotating the latter the tripod tends to be carried round, the torque on it being measured by a spring gauge. In this machine the static friction when a vegetable or animal oil was used as the lubricant, was markedly less than it was with mineral oils. There seems, indeed, quite a fair prospect that in this machine we have an instrument which will serve to determine by a rapid laboratory test the "oiliness" of any proposed new lubricant.

Mr. Deeley's observations have been confirmed by the results of other observers. Indeed, at Friday's meeting, the discussion turned almost wholly on this adsorption of good lubricants by the surfaces to which they are applied. Lubrication was, in short, considered almost solely as a problem in Physical Chemistry, but it is certainly much more than this. The mechanical aspect of the question was little dealt with and, indeed, some of the speakers had evidently given little consideration to the matter from this point of view.

In one of the memoranda submitted, for example, it was stated that when a fully-lubricated spindle revolves eccentrically in its bush, the resultant pressures set up act in such a direction as to tend to diminish the eccentricity. As a matter of fact, this is not the case, the resultant pressure, in fact, acts at right angles to a line drawn from the centre of the spindle to the centre of the bush. Here, no doubt, is to be found the explanation of the curious result established by Harrison, to which Dr. Stanton drew attention at Friday's meeting. Harrison found that the drag of the oil on the bush was less than the drag of the oil on the spindle. or, in other words, that the torque on the bush was not the same as the torque on the spindle. There is thus an unbalanced torque, which must be accounted for in some way. This would be impossible if, as was suggested in the memorandum in question, the resultant pressure on the bush acted along the line of the centres. As a matter of fact, the resultant does not pass through the centre of the bush, and has, consequently, a torque about the latter, which

establishes the necessary equilibrium between action and reaction.

Another speaker asserted that, if a drop of liquid which wetted the metal, were introduced between a shaft and its bush, the effect would be to lift the shaft. As a matter of fact, the exact reverse is the case. It is well known, for example, that if a drop of water be introduced between two flat and clean pieces of glass, the two are drawn into such close contact that the surfaces may be injured. In another note submitted it was suggested that "we may picture each of the metallic surfaces covered with a layer of oil one molecule thick, resembling a piece of velvet firmly glued to the metal with the pile outwards. Two such velvet surfaces can glide over one another with but little friction." Now, as a matter of fact, velvet surfaces are typically rough surfaces and do not glide over each other easily. An older form of the velvet pile theory attributed a structure of this kind to the molecules of the metallic surface. It was suggested that the fact that the "running in" of a bearing reduced the friction was due to the pile being all stroked in the same way, and that the increased friction found on reversing the motion was due to a ruffling up of the pile. Again the fact that, in general, it was found better to run a steel shaft in a bronze or white metal bush was attributed to the fact that with dissimilar metals the pitch of the successive fibres of the pile was not the same, and thus less interlocking of the surface molecules was possible than when both bush and journal were of similar materials. In this connection it may be noted that the existence of such a pile presumes some kind of fibrous or crystalline structure on the surface layer of the metal. Actually, as Beilby has shown, the surface layer of a polished metal is non-crystalline, and is amorphous, being, in fact, an undercooled liquid. Further it may be observed that in Mr. R. M. Deeley's experiments, the static friction was higher between steel and lead bronze than between steel and cast-iron, though on the hypothesis criticized the intermeshing would be expected to be greater with the more similar metals.

The real explanation of why there is a rise of friction on reversing the motion o a shaft was given by Osborne Reynolds, and to his view of the matter later experiences have added additional weight. He believed that the effect of running a journal in one direction was to improve the bedding of the brass. On reversing the motion the trailing side of the brass becomes the leading side, and the journal has to re-bed itself. The value of such materials as lead, bronze and white metal for bearings appear to be due to the fact that both flow more readily under pressure than harder materials, and the automatic bedding of brass to journal is effected both more rapidly and more effectively than if the bush were of harder materials.

Mr. R. M. Deeley, in his paper, observes that "clean metallic surfaces in frictional contact soon tear each other and heat, but when a lubricant is interposed it unites with the metals, forming a solid which is itself a lubricant." In our view this can hardly be accepted as an ultimate explanation of the phenomenon. The question at once arises as o the mechan sm at work in such lubrication. The typical self-lubricating solid is ice. But ice is not slippery at very low temperatures, although there is no reason to believe that the character or constitution of its surface is changed by lowering its temperature. Osborne Reynolds' explanation of the matter is that when near its freezing point ice melts under pressure. A lubricating film of liquid is thus automatically provided under a skate sliding over it. The lubrication is thus due to the presence of a liquid film between the opposing surfaces. At very low temperatures this film is not formed, and the ice is no longer slippery.

Osborne Reynolds further maintained that in imperfectly lubricated bearings th.3 mechanism involved was exactly the same as in fully lubricated bearings. Lubrication, in his view, was in this case also due to the presence and maintenance of a fluid film between the journal and the brass, but the load was, in the case of imperfect lubrication, supported on but a limited area of the brass. Indeed, metallic contact between the two might occur at places probably intermittently, but such places are ineffective for supporting the load, and if contact is continuous rapid wear and ultimate seizing is certain.

It is a very good rule not to introduce new theories or hypotheses before the facts make it necessary. It is known that Osborne Reynolds' theory is in thorough accordance with the facts when lubrication is complete. Is there any sufficient reason for assuming that a different kind of mechanism is required to explain the lubrication of bearings but scantily or intermittently supplied with oil?

It seems to us that Osborne Reynolds' theory can be readily adapted to Mr. Deeley's results, Osborne Reynolds assumed that lubrication broke down when the motion of the film of fluid between the opposing surfaces became turbulent. It is, however, difficult to believe that in actual practice the conditions are ever such as to admit of this occurring. On his theory, however, lubrication would equally fail if the revolving shaft were unable to drag in underneath the brass the supply of lubricant necessary to maintain the film. In other words, if a slip occurred at the boundary between the solid and the liquid, lubrication would fail. Obviously, the firmer the adherence between the lubricant and the solid surface, the less is the possibility of such a slip at the boundary occurring. Where the shear stresses in the film are small, any fluid will serve as a lubricant, because the adhesion is sufficient to permit of the journal dragging in the supply necessary to maintain the film. In the case of scanty supplies of lubricant, however, the load will be concentrated on small areas of the brass and the film at these points will be extremely thin, and the shear stresses on it accordingly very high, far in excess of the stresses realised in such experiments as have been made to determine whether or no slip is possible at the boundary of a liquid and solid. Thus in an article on the lubrication of gear teeth, published in our issue of August 11, 1916, page 119, it was shown that in turbine reduction gears the thickness of the oil film between the teeth was of the order of $\frac{1}{5,000}$ in., and that the pressure in the oil film was as much as 3 tons per sq. in. Under these conditions the shearing stress on the oil, tending to make it slip on the tooth surfaces was over 20 lb. per sq. in. In the above calculation it was assumed that the load was uniformly distributed over the whole length of the tooth and that it amounted to 520 lb. per linear inch of the width of the gear wheel and to 267 lb. per lineal in. of tooth. Actually it is found, in practice, that at times and in parts the surface of the teeth flows in service, so that the pressure developed in the film must at times be far higher than the 3 tons per sq. in. calculated on the hypothesis of uniform distribution of the load. Nevertheless, even although the metal flows, lubrication (with good oils) is fully maintained and there is neither excessive heating or undue wear. In that case the film must be correspondingly thinner, and the shear stresses on it, may well attain to 100 lb. per sq. in. or more. Under such conditions, the adhesion between the oil and the metal will be severely tested, and there seems nothing inherently improbable, that though the bond holds with those lubricants, which, in Mr. Deeley's view, "weld" themselves to the surface, it may fail with the non-oily liquids. In that case the film between the teeth would cease to be maintained and rapid cutting of the surfaces might be expected. If, as Osborne Reynolds supposed, the load in imperfectly lubricated bearings is concentrated on a very small area of the brass, there seems every reason to believe that here again excessively high pressures and shears may be developed in the film. With white metal and lead bronze bushes these high pressures will tend to make the metal flow and increase the effective bearing area. With a good oil, lubrication will be maintained because, owing to its high adhesion to the surface of the journal, fresh supplies can be dragged in and the film between the opposing surfaces be permanently maintained.

There is, moreover, direct evidence that the adsorption of a lubricant by the bearing surfaces cannot be the only factor involved in the satisfactory operation of scantily lubricated surfaces. Lord Rayleigh, for example, found that when a glass tripod rested on a glass plate, the friction was high when the surfaces were chemically clean. In view of the hygroscopic qualities of glass, it would, however, seem that, in these conditions, there must have been a film of water on the surfaces used, and such a film would be highly adherent. On sullying the surfaces with the merest trace of oil, the friction between tripod and glass was astonishingly reduced, and on the view above put forward, this fact would be attributable to the greater viscosity of the oil.

A curious anomaly in these experiments seems also explainable without departing from Osborne Reynolds' theory. Lord Rayleigh found that, although the friction was small, with a mere trace of grease or oil on the glass, a further addition of lubricant caused a notable increase in the resistance to sliding. Now there is ample evidence that the adhesion of a film only a molecule or two thick to a surface is higher than if these molecules are buried under other like molecules. Hence on the hypothesis put forward above, with the additional supply of lubricant giving a thick film, adhesion failed under the heavy shears developed and the lubricating film between the tripod and the plate broke down.

It should, perhaps, be noted in this connection that the feet of the tripod used in Mr. Deeley's machine are only commercially flat. A convexity of a millionth of an inch would give room for a layer of oil, perhaps a 100 molecules thick. It is, perhaps, impracticable to ensure that the error in the shape of the surfaces shall be small compared with the molecular dimensions, but some interesting results might be expected if this desideratum could be attained.

DIRECT ACTION.

There are many methods open to win a desired end, the least effective is often the most brutal; a flank attack is less crude, it involves more skill, a finer sense, and more subtle means, than frontal mass tactics. Tact and diplomacy are not of necessity vicious, they avoid rousing hostility on minor issues, even plausible manners have their uses, and politeness need not involve cringing. It is often want of intelligence which leads to the selection of the more primitive method, although it is equally certain there are times when soft words are misconstrued, and when kindness is cruelty, or, perhaps better said—it is necessary to be cruel to be kind.

The hand of steel in the velvet glove is proverbial, the armour of innocence is less recognised, the value of suffering fools gladly having an ulterior objective in view is daily practised by those out to win any end a long way off. Direct action is primitive; even Nature tempers her processes of creative growth by imperceptible stages; where she is direct, she is destructive; where she is creative she is infinitely patient, taking countless ages in some instances to effect her purpose. No one is more aware of the need for indirect approach than the man of science and his disciple and coadjutor the engineer. Every time the new device or projected experiment fails, a new beginning from the proven start, or patient readjustment, is made. No sane individual smashes the work in hand with a hammer. Even in a game or pastime it is creditable and sportsmanlike to accept defeat in order to venture skill again in the near future.

Skill consists of the patient upbuilding of detail, just as science is a never-ending sequence of experiment founded upon reason and previous knowledge. The impossible obstacle is outflanked, the cunning of the craftsman takes the longer way round, and by indirect means achieves results. If direct action were enough, then any common-sense individual could without apprenticeship or training obtain without difficulty the results of a master hand. There may come a time when evolution will have so advanced mankind that thought and deed will be simultaneous, when speech will be unnecessary and intention alone be sufficient, but human limitations as we know them at present preclude such counsels of perfection. To achieve greatly means endless preparation. It was a well-

known musician who complained that one life was only sufficient to learn, he wanted another to practice. The same idea must have occurred to many whose life's activity was an absorbing interest and mastery in a complete sense was never possible. Such an existence where the incomplete is always being made less imperfect, where every day brings its own result to effort by adding experience and knowledge, is the reward of those who enter a business where by infinitesimal gradation, a never attainable result is sought. Mechanism is such a profession, and its enthralling nature is only realised by those whose temperament reacts to its fine stimulus, a lifelong interest is no small compensation in an otherwise troublesome business—that of living.

The point at the moment is, if the end could be obtained by direct action, interest would vanish. It is the subtle provocation to achieve, by pitting intelligence against the problem in hand in order to obtain a practicable result which lends all the interest; it is indirect action which furthers mechanical evolution. Subsequent stages may be more direct, but the beginning must be tentative, and in practice the first attempt is never successful. Latterly the term direct action has come to mean industrial rebellion, throwing the gage of battle to society, refusing negotiation; for relatively trivial issues sections of organised units in industry have sought to make certain of their particular reward, by penalising everyone else. Apart from real grievance, such action is against natural law and has no precedent elsewhere, otherwise all were chaos, more can always be achieved by indirect than by direct means. Co-operation and unity apply as much to civilisation at large as to the rectification of small grievance.

The cost of the railway strike will fall with cheerless impartiality upon the striker as well as the public, just as the rain falls on the just and the unjust alike. Direction is the more successful when applied in the least direct manner, men can be led or coaxed rather than driven, as in all human relationships direct action defeats its own ends. Management is the most efficient when least obtrusive; it is possible, nay essential, to be direct in the punishment of crime or the handling of convicts, the difference between the free and the bound is most pointed in this particular. When free men become direct, they unleash rude force to win a limited goal; forgetting that the result of the inartistic is always to give pain and cause distress, and more especially does fear always fail in its effect. The first plunge is unpleasant, the first shock acute, but just as intelligence never won discovery by lack of subtlety, so even fear loses its compulsion when faced after the first reaction. The lesson of the recent period just closed, is that applied might is powerless in the long run before the cumulative effect of outraged right; civilisation cannot allow any adverse minority to impose its will by methods of tyranny or anarchy.

The application is universal at all levels, the penalty for mass action is mass distress, it is no triumph to win a priviledged position upon the sufferings of others. The very spirit which leads to such perverted views must be destroyed. In a democratic community where representation is common to all alike, real wrong obtains eventual redress, only impatience counsels direct action. In any difference of views, if one antagonist uses intemperate speech he weakens his case, in like manner violence is no substitute for justice, a full and impartial hearing is always precedent to sentence.

We are all members of an entire whole, the default of the part or of any detail leads to paralysis; and should direct action become a general resource against grievance fancied or real, it will end all that time has reared by the same human hands who wrought its first beginning. In more senses than one mankind is at the cross roads, in its hands lie weapons none the less deadly because not directly violent, to withhold the means of living is just as certain in its effects as the quicker method of cold steel or high velocity bullet, the latter indeed may be the more merciful. In the last analysis altruism is the only policy, service the only ideal worth imitation, individual aggrandisement has lost whatever glamour it ever possessed. Direct means are reactionary and fail of their objective, and the substitution of one tyranny for another will, it is hoped, find few adherents.

ENGINEERING SCHEMES IN PARLIAMENT.

THE private Bills to be promoted during this session of Parliament are for the most part of a very humdrum character. Neither the financial nor the political circumstances of the time are such as to encourage much display of enterprise.

Under present conditions the high rate at which alone money can be raised is of itself sufficient to explain the fact that only one of the principal railway companies is submitting a Bill. This exception is the Great Northern Railway Company, which is seeking powers to execute certain important widening works. On the main line these are to be effected on the section between Grantham to Sutton, which lies a little north of Retford. The Grantham to Nottingham line is to be widened near Grantham and from Bottesford to Belvoir Junction. It is further proposed to construct a new line from the company's Waltham Branch, near Melton Mowbray, to connect with existing line at Colsterworth, near Grantham.

A new company is promoting a Bill authorising the construction of a new railway through the Derwent Valley, from Grindleford, on the Dore and Chinley Branch of the Midland Railway, to Hassop, on the Manchester Branch of the Midland line. The Central London Railway Company and the Metropolitan District Company are promoting a joint Bill, providing for the construction of junctions at Hammersmith between the metals of the Central Company at Providence Place and those of the London and South-Western Railway, Richmond Branch, near Shepherd's Bush station.

In another clause powers are taken for the enlargement of Aldgate East station. In a separate Bill the Underground Railways seek general powers to increase fares. The Huddersfield Corporation include in their Omnibus Bill clauses providing for the construction of new branches in Huddersfield, from the Midland goods yard to their gas works and sanitary depot. Another branch is to join up with the corporation trams. It may further be mentioned that in connection with their proposed new water works the Newport Corporation seek powers to construct a temporary line from Pant-i Rhiw station to the site of the proposed dam across the Caerfanell stream.

There are but few proposals for the construction of light railways. The most important seems to be that described in a Bill privately promoted for constructing a line through the Fens from near Shippea Hill station, on the Great Eastern line near Ely, to a junction at Methwold with the Wissington Railway. This branch will be 9 miles long, and there is to be an extension 4 miles 5 furlongs long to West Dereham, where there will be a connection with the sidings of the Great Eastern Railway (Downham and Stoke Ferry Branch). A branch, 2⅝ miles long, will extend from Anchor Drive to Southery.

In another private Bill powers are sought to construct light railways from Warthill station, near York, to the stockyard of Barnby House and the Glebe Farm at Scrayingham. The Southend Corporation ask leave to construct a line joining up railways 1 and 3 of their Order of 1899, and the Brighton Corporation to extend as a light railway their trams along the Lewes road.

The only striking new proposals for tramways are those made by the London County Council, which, it would almost appear, are designed to increase still further the congestion of the streets of the metropolis. In an official report issued some years since by the Board of Trade, it was estimated that if the obstruction caused by a tramcar was taken as 7, that due to a motor 'bus was represented by 3. Further experience has certainly not conduced to a more favourable estimate of the relative drawbacks to the two systems of urban transport. Falstaff claimed that he was not merely witty in himself but the cause of wit in others, and the London County Council tramcars are not merely slow and cumbrous conveyances themselves, but greatly hinder the progress of other traffic. In face of these notorious defects which, as compared with provincial tramway systems, are aggravated by the presence in the middle of the street of the most objectionable slot, the County Council are proposing extensions through some of the most heavily-travelled streets in London, and seek in addition a right-of-way through Hyde Park. In all, 16 new lines are proposed. Of these, No. 1 will join up the existing tramlines in Farringdon-road with those over Blackfriars Bridge and along the Embankment. Tramway No. 2 will extend from the present terminus in Gray's Inn-road, across Holborn, and along Charterhouse-street, joining up there with the proposed new line to Blackfriars. Tramway No. 3 is to extend the existing lines in Hampstead-road, along Tottenham Court-road and Charing Cross-road, to the National Gallery, with a branch (Tramway No. 4) from Cambridge Circus and along Shaftesbury Avenue and Hart-street to a junction with the existing lines in Theobalds-road. By Tramway No. 5 the existing line in Vauxhall Bridge-road is to be extended along Victoria-street to a junction with the existing lines over Westminster Bridge. Tramway No. 6 is to commence in a junction with the existing lines in Edgware-road, enter Hyde Park by a new gate, and, passing out at Hyde Park Corner, extend down Grosvenor-road and Victoria-street to the existing lines in Vauxhall Bridge-road. By Tramway No. 7 the existing lines of the Middlesex County Council at Cricklewood are to be extended along the Broadway, High-road, Kilburn, Maida Vale and Edgware-road, to a junction with the proposed Hyde Park tramway. Tramway No. 8 is a branch connecting the existing lines in Edgware-road with King's Cross, the route followed being along Marylebone-road and Euston-road. Tramway No. 9 is to extend from Shepherd's Bush to the Marble Arch, passing along Uxbridge-road, High-street and Bayswater-road. By Tramway No. 10 the existing lines at Stamford Hill are to join up at Clapton Common with the tramway there. The route followed is along Amhurst Park-road. By means of Tramways Nos. 11 and 12 the Whitechapel lines are to be carried on to Tower Hill and the Minories, the direction taken being along Aldgate High-street and Mansell-street. Tramway No. 13 is to connect lines in Southwark-street with those in Tooley-street, passing along Southwark-street, Borough High-street and Duke-street. Tramway No. 14 is a junction line between the metals in Waterloo Bridge-road to those in Blackfriars-road, passing along the New Cut and Great Charlotte-street. Tramway No. 15 is to connect up Forest Hill with the Crystal Palace. There will be a junction with the existing lines in Beckenham-road and the new track will be laid along Dartmouth-road, Sydenham Park-road, Sydenham Park, Kirkdale, Lawrie Park-road and Crystal Palace Park-road. Tramway No. 16 will extend from West Norwood to the Crystal Palace, along Robson-road, Park-road, South Croxted-road, the Avenue, Dulwich Park-road, Dulwich Wood Park and Farquhar-road.

The Middlesex County Council has also a proposal for a new tram line, 1⅞ miles in length, along the Edgware-road. Many provincial towns are also proposing to lay new track, but much of this will be simple short junctions between lines already existing. To this end Bills are promoted by the public authorities at Blackpool, Cardiff (⅞ mile), Coventry, Edinburgh (2¼ miles), Halifax (2¾ miles), Huddersfield, Manchester, Newcastle-on-Tyne (6½ miles), Nottingham, Pontypridd (2¾ miles), Portsmouth, St. Annes-on-the-Sea (¼ mile), Salford (5 miles), Sheffield, Southampton and Warrington.

A purchase Bill is being promoted by the Corporation of Stoke-on-Trent, whose intention is to acquire the undertakings of the Potteries Electric Traction Company, Limited, and of the North Staffordshire Tramways Company, Limited. It may also be noted that many of the above corporations, and also some companies, are seeking powers to raise fares either generally or on special occasions.

The only trackless trolley proposal appears to be one submitted by the Corporation of Lowestoft. Possibly if the super-electric power station comes

into vogue, schemes of this type may perhaps regain much of their former popularity.

It is, we think, generally recognised that the motor-'bus would never have passed through the perils of infancy, if it had depended on the fostering care of the municipalities. The difficulties overcome were extraordinary. In the infancy of the system a three days' run without a breakdown was considered as exceptional, and the temptation to make political capital out of such failures, had the enterprise been undertaken by a public authority, would have led to the early abandonment of the experiment. Fortunately for humanity, the London Omnibus companies showed more persistence, and bit by bit learnt how to construct the vehicles which before the war gave London an unchallenged supremacy in the matter of urban transport, and when the crisis arose were available for military service in France. Now that the costly and risky pioneering stage has been successfully surmounted the municipalities are anxious to reap where private enterprise has sown, and the Omnibus Bills of many public authorities seek extensive powers for the running of motor 'buses not merely within their own boundaries, but to outlying districts, either with or without the consent of those representing the districts invaded. A list of these public authorities is as follows: Bootle, Bridlington, Cardiff, Coventry, Edinburgh, Erith, Folkestone, Gelligaer, Huddersfield, Leigh, London (County Council), Lowestoft, Middlesex (County Council), Newcastle, Nottingham, Risca, Rhondda, St. Annes-on-the Sea, Salford, Sheffield, Stoke-on-Trent, Sutton Coldfield, Swansea, Wallasey and Wolverhampton. The Tyneside Tramways Company are promoting a Bill giving them powers to run 'buses in connection with their tramway undertaking. In certain cases the local authorities seek powers to compel motor-'bus proprietors to make further contributions to the upkeep of the roads. No similar demand is made from motor-van owners, and, indeed, in a Board of Trade report issued a few years ago it was stated that the contributions to road upkeep already made by the motor 'buses was relatively higher than that derived from tramway undertakings. Of course, at that date the petrol duties, since diverted to the general funds of the Exchequer, were earmarked for road construction and maintenance.

In view of the Government proposals for promoting the development of cheap electric power in this country it is not surprising that little enterprise is being shown in this connection by others. An interesting scheme is that proposed by the Dartmoor and District Hydro-electric Supply Company. In their Bill, this company seek powers to erect a whole series of dams across the Dartmoor waterways, and to use the water thus impounded for the operation of hydro-electric generators. Thus the North Teign River is to be dammed near Teign-i-ver Clapper Bridge. Weirs in the Lydford district are to be constructed over three unnamed streams flowing into the South Teign River, and the latter stream is itself to be dammed near Fernworthy Bridge. A third reservoir is to be constructed in the Okehampton district by embanking the River Taw, and a fourth by a dam across the River Tavy near Redlake. There is also to be a weir across the Youldon Brook, near Wapsworth Bridge. A fifth reservoir is to be constructed on the East Dart River, near its junction with Birch Tor; and a sixth by banking the Dart near Dartmeet Bridge. The waters of the Erme are also to be impounded near its confluence with the Redlake Brook. Two other weirs are proposed across the Erme and the Piles Brook respectively.

In their Omnibus Bill, the Newcastle-on-Tyne Corporation take powers in certain cases to supply current to works along their tramway routes. The Bristol Corporation seek to extend their area of supply to a number of out-lying areas beyond the city boundaries, and a proposal of a similar character is made by the Corporation of Huddersfield. Provisional Orders for supplying electric energy are sought by the local authorities for the following districts: Bedwas and Machen, Eston, Havant, Nanty-glo and Blaina, Mynyddislwyn, Risca, and Tredegar, whilst a purchase Bill is being promoted by the Urban District Council of Masham. Private promoters are seeking Orders for the following areas: Abersychan, Ammanford and District, Panteg and Saint Mellons.

The Corporation of Newport propose to construct a new reservoir by damming the Caerfanell stream in Brecknockshire. The construction of this reservoir will necessitate the diversion of the road between Talybont and Tarpantau railway station. Subsidiary works comprise the construction of a service reservoir at Llantarnam. The Derwent Valley Water Board propose to construct a new reservoir on the Derwent just below their existing Derwent reservoir. Included in the Bill is a proposal to build a weir across the Ashop River, near its confluence with the Alport. An enlargement of their Shon Sheffreys reservoir is proposed by the Urban District Council of Tredegar; whilst new filter beds are to be constructed by the Cardiff Corporation at Cantreff; together with a relieving tank near the Gortrecoed Lock on the Glamorgan Canal, and a service reservoir at St. Andrews Major.

The constitution of a Water Board for Mid Glamorgan forms the subject of another private Bill. This body is to be constituted by representatives of the Glamorganshire County Council and the local authorities of Ogmore and Garw, Maesteg, Glyncorreg, Porthcawl, Pennybont and Cowbridge. The water is to be obtained by weirs across the Afon Corrwg and the Nant Lluest-wen, and from intakes from the Garw-Fechan, Nant-Bryn-Cynan, Nant Cedfyw, Afon Garw, Nant Iechyd, Nant Cwm Ffaeg, Nant Cwm-y-Ffynnon, Nant Cwm Gadlys, Ogwr Fawr, Nant-y-Ffosp, Nant-Bryn-Cynan, and other streams. The Liverpool Corporation propose the construction of a fourth pipe line from Vyrnw. In Scotland the Burgh of Denny and Dunipace propose to enlarge Loch Coulter by a dam across the Auchenbowie Burn. A purchase Bill is being promoted to transfer to a proposed Dearne Valley Water Board the undertaking of the Dearne Valley Waterworks Company, and of the Wombwell Urban District Council. A similar proposal is that set forth in a Bill for acquiring the works of the Weardale and Consett Water Company. This latter company is itself promoting a Bill authorising the construction of new pipe lines and an increase of rates.

Other purchase Bills are those promoted by the Norwich Corporation and by the Drayton Urban District Council.

The Merthyr Tydfil Corporation propose to construct new intake weirs across the Nant-y-Wern and its tributaries. The Tees Valley Water Board seek powers for a new well and pumping station and service reservoir at Ormesby. The Rhondda Urban District Council in their Bill propose to erect a new pumping station at Blaen Clydach, and to construct a new service reservoir at Rhondda. A new well and pumping station in the Epsom area is proposed by the Corporation of Croydon, with powers to give a bulk supply to Epsom. The Yeovil Corporation seek powers for a new well and pumping station at Cattistock, and for a new service reservoir at Sydling St. Anthony, and a collecting tank at Melbury Bubb. The Downside Water Company, Limited, are seeking powers to supply Stratton-on-the-Fosse, Ash Church and Midsomer Norton. Several water authorities, it may be noted, are proposing to increase their rates.

With one exception the gas Bills are practically without interest, relating almost exclusively to proposals for altering sliding scales or for adopting a calorific standard for the gas supplied. The exception is the proposal of the Sheffield Corporation to acquire the works of the Sheffield Gas Company, which has, we believe, the credit (at least in pre-war days) of supplying the cheapest gas and paying the largest dividend of any undertaking in the kingdom. Purchase Bills are also being promoted by the local authorities at Sunderland, Masham, and Redcar. It may perhaps also be noted that the Tredegar Urban District Council is seeking powers to purchase coke-oven gas for supplementing the supply from its own retorts. This plan has proved very successful in Germany.

The Mersey Docks and Harbour Board propose to construct considerable lengths of new river wall as a northern extension of their landing stage, and the St. George's landing stage is also to be extended by 50 yards. Further new river wall is to be constructed near the Herculaneum Graving Docks, and a new dock is also to be built in this area. Messrs. Lever Brothers, Limited, also proposed to construct new works in the Mersey at Bromborough. These include a new river wall or wharf and an island wharf further out in the stream, which will be connected by a bridge to the bank.

The proposal to construct a new ocean wharf in the Thames at Canvey Island, near Haven Hole Coast Guard station is revived in a Bill promoted by the Thames Ocean Wharf and Railway Company. The wharf is to be connected by rail with the Midland line at Pitsea and with the Great Eastern Railway at Fanton Junction. In view of the attitude of Parliament to any infringement on the monopoly of the London Port Authority there is perhaps little chance of any such scheme being considered on its merits.

The Dover Harbour Board propose to construct a new wet dock and two new dry docks, as well as new quays in the Wellington Basin, and in the Granville Basin. The construction of over 3 miles of new training walls are proposed by the Tees Conservancy Board. This will take in practically the whole of the still unreclaimed portion of the Seal Sands. Other Bills relating to marine or river works are of little engineering interest, but it may be noted that many port and harbour authorities are taking power to increase dues.

During the past five years street and road improvements have been for the most part postponed for the duration of the war, but now many towns are seeking powers to carry out much-needed street widenings and extensions. Proposals for works of this character are included in the Bills promoted by the local authorities at Blackpool, Bristol, Cardiff, Coventry, Erith, Gelligaer, Halifax, Huddersfield, Manchester, Merthyr Tydfil, Nottingham, Pontypridd, Sheffield, Swansea, Whitley and Wood Green.

The Norwich Corporation seeks powers for constructing a new opening Bridge over the River Wensum, and the Lee Conservancy Board ask powers to prepare preliminary plans for checking floods in the Lee Valley.

Of special interest to engineers is the Bill promoted by the Institution of Civil Engineers empowering them to keep a register of qualified civil engineers and to hold examinations for admission to the list. A clause in the Bill prohibits the use of the title of Civil Engineer by unqualified men who are further declared by the Bill incapable of giving certificates for work done, or of securing fees by legal process. Provision is made for the protection of existing interests.

LUBRICATION.

Physical chemistry was to the front when the Physical Society discussed "Lubrication" on Friday last—not inappropriately, yet possibly a little more than was desirable or necessary. The mechanical and dynamical aspect of the problems was mainly urged by two speakers, Dr. Stanton, who opened the discussion, and Mr. H. M. Martin, upon whom Professor C. H. Lees, F.R.S., president of the Physical Society, called at a late hour, and who had to content himself with a few remarks. The physical and chemical problems are no doubt important, and Mr. Deeley's contribution on "Oiliness and Lubrication" was certainly very acceptable to the engineer. But some of the speakers drifted away from the subject, with unsteady helm and questionable inferences, and Professor Lees, in closing the discussion, admitted that he had made little progress as to the understanding how lubrication came about, though important suggestions had been offered.

In introducing the discussion, Dr. T. E. Stanton, F.R.S., remarked that the last forty years' work on the phenomena of lubrication had practically been devoted to the particular case of cylindrical or flat surfaces under moderate loads with an unlimited supply of lubricant. Our knowledge on the phenomena under these conditions was chiefly due to Beauchamp Tower's researches carried out in 1883 for the Institution of Mechanical Engineers.

Experimenting with a cylindrical journal, carrying a half-bearing on its upper surface and dipping into an oil bath at its lower surface, with loads ranging

from 100 lb. to 520 lb. per square inch, at speeds ranging from 100 r.p.m. to 750 r.p.m., Tower found that the resistance was practically independent of the load, and nearly proportional to the speed, and that it changed with temperature. The conditions were consistent with the assumption that the surfaces were separated by a thin film of oil in steady motion; the assumption was verified by inserting pressure tubes in the cap of the bearing when the vertical component of the pressure was found to be equal to the load. Osborne Reynolds soon afterward showed that the equations of hydrodynamics could be applied to these conditions, and obtained an approximate solution in two dimensions for the case of a semi-cylindrical bearing. With a journal turning anti-clockwise there would be a negative pressure area on the left, and a positive pressure area on the right, and on applying a load the positive area would exceed the negative area by the amount of the load, and the bearing would consequently tilt, so that the point of nearest approach, first immediately above the centre of the shaft, would shift over to the off side. Equilibrium would always lie on the right of the vertical through the centre of the journal, however, and on increasing the load a limit would be reached when the pressure of the oil film on the left of the bearing would sink below atmospheric pressure and rupture of the film would tend to take place.

In 1904, Somerfeld had improved the mathematical treatment of Reynolds, and A. G. M. Michell (of Melbourne) had, in 1905, extended the solution to three dimensions for flat surfaces. In 1913, then, Harrison had by direct integration obtained a comparatively simple equation for the pressure distribution, and had demonstrated also that an appreciable difference might exist between the moments of friction on the journal and on the bearing; the former might, under certain conditions of Reynold's paper, be twice the latter. Bath lubrication was not common practice, however, and with a limited oil supply different relations of speed, &c., prevailed. In Tower's experiments rupture of the film and seizing of the journal had taken place at about 520 lb. per square inch. During recent years the attention of engineers had been directed to the possibility of very efficient lubrication at very much higher pressures. Dr. Stanton in this connection briefly referred to the experiments on the transmission of power through worm gearing conducted at the National Physical Laboratory, at pressures up to 5 tons per square inch, in which efficiencies of 97·5 per cent. were quite common. It was found that a frictional resistance of the gear was, at 40 deg. C., the same with castor oil as with Trotter oil, although the viscosities of the two oils were, at that temperature, as 6 to 1. Experimenting with vegetable, animal and mineral oils, Mr. H. J. Hyde had observed that the efficiencies of the former two oils changed very little with temperature, whilst those of mineral oils fell off rapidly about 40 deg.; but mineral oils could be much improved by small additions of vegetable oils. Raising the pressure to 900 atmospheres increased the viscosity of vegetable and animal oils up to four times, that of mineral oils 16 times; but viscosity was clearly not the only factor to be considered.

Mr. R. Mountford Deeley had sent in an important paper on "Oiliness and Lubrication," which was communicated by the Lubricants and Lubrication Committee. In his absence the paper was read in abstract by Mr. Barnes, a member of the committee, and Mr. Hyde subsequently demonstrated the use of Mr. Deeley's new apparatus for testing oiliness, with which he is now experimenting at Teddington. It would seem that the apparatus requires very delicate handling; the influence of minute contaminating films is very great; we note the statement made by Mr. Deeley that breathing upon a surface for 2 seconds raised the static coefficient from 0·160 to 0·452, the latter being an exceptionally high value; but all the speakers certainly welcomed the oiliness tester.

Mr. L. Archbutt, who was first called upon by the President, pointed out that two prevailing conditions should clearly be distinguished in lubrication problems: (1) Cases when the two solid surfaces were completely separated by a film of oil, as with properly-fitted journals revolving at high speed and abundantly fed with oil, and (2) cases when owing to the shape or condition of the surfaces, low speed, high pressure, or inadequate oil supply, the oil film could not form completely or became broken so that the solid surfaces came into contact. In case (1) the friction was entirely due to the viscosity of the oil, and the theory of Reynolds and study of the physical and chemical characteristics of an oil could guide us. In case (2) circumstances were entirely different, and we had to rely on trials. Oils alike in viscosity might have different friction-reducing values; we did not know why mineral lubricants were inferior to animal and vegetable oils, and we could only say that viscosity was not the only or the most important factor; some other unknown property termed oiliness was very important. Mr. Deeley's ingenious machine seemed likely to give a valuable means of measuring that oiliness, and his view that oiliness enabled the oil or some constituent of it to combine with the surface and to form a lubricating film was in accordance with Langmuir's view. The importance of the friction surface was familiar to engineers. Mr. Archbutt recently found that, under the same conditions of speed and pressure and with the same oil, bearings of white metal would carry double the load of bronze bearings without increase in friction. According to Goodman traces of metals of a smaller atomic volume than the white metal alloy increased the friction.

On Langmuir's theory the molecules of the oil and solid were held together by residual or secondary valencies; the more chemically active the lubricant, the more firmly it would be attached. Mr. Southcombe's discovery [presently to be mentioned] of the importance of the fatty acids was therefore of great interest. Free acids had so far been considered injurious in lubricants, because they corroded metals and formed soaps thickening the lubricant in the presence of steam or merely of moisture. According to Southcombe very restricted amounts of fatty acids were an advantage, but there again the conditions had to be considered. In case (1) the fatty acids were of no advantage; in case (2), solid friction, the effect was remarkable. Experimenting with a Thurston machine at low speed, 7 ft. per minute, and pressure of 270 lb. per square inch, Mr. Archbutt had found that 1 per cent. of the fatty acid of rape oil added to a mineral lubricant lowered the coefficient of friction from 0·0047 down to 0·0033, and that 2 per cent. of the acid did not effect any further lowering. Of neutral rape oil 60 per cent. were required to produce the same effect; it was in that respect rather fortunate that commercial rape oil always contained some fatty acid. The important point was that a small percentage of fatty acid improved the lubricating power of a mineral oil as much as a large percentage of fatty oil. But it was also noteworthy that he had found a perfectly neutral rape oil to give lower friction than a mineral oil of the same viscosity. In comparative tests made with a commercial rape oil of 2·4 per cent. of fatty acid R, with a perfectly neutral oil R_1 prepared from R, and with a mineral oil M of the same viscosity, he had obtained the following friction coefficients: $M = 0{\cdot}0078$, $R = 0{\cdot}0050$, $R_1 = 0{\cdot}0045$. These results, if confirmed, would suggest that the oiliness or lubricating efficiency of the unsaturated molecules of the neutral rape oil was nearly as great as that of the free fatty-acid molecules, but that the acid molecules were much more active in their influence on the hydrocarbon molecules of the mineral oil. The size of the molecules and the thickness of the molecular layer would be important factors, and Langmuir's researches seemed to throw considerable light upon the subject.

Further attention to Langmuir's work on films was drawn, in a note on "Molecular Layers in Lubrication," by Dr. H. S. Allen, of Edinburgh University, who also referred to Principal Skinner in this connection. Langmuir regards the adsorption of liquids or gases at the surface of solids, in layers, only one molecule thick frequently, as a result of unsaturated chemical forces at the surface. For similar reasons a liquid may or may not spread on another, water *e.g.* The soluble glycerin-ester end of the rod-like molecule of a fatty lubricant tends to dissolve in the water; the insoluble hydrocarbon end does not dissolve; the molecules thus stand on end, and the water surface becomes covered with a layer of closely-packed molecules of vegetable and animal oils. Mineral oils, on the other hand, have hydrocarbon groups at each end and refuse to spread. Applying Langmuir's theory to lubrication the metal would cover itself with a layer of oil one molecule thick, resembling a piece of velvet firmly glued to the metal with the pile outward, and two such velvet-clad surfaces would glide over one another with but little friction. On that view, Dr. Allen suggested, oiliness would depend neither on viscosity nor on compressibility, but on chemical forces and on the nature of both the lubricant and the metallic surface.

Principal Skinner, M.A., remarked that what he had intended to say would be a summary of the views already expressed. He mentioned experiments of his made with oil bearings consisting of two coaxial glass cylinders; when the outer cylinder was rotated, the torque on the inner suspender cylinder tended to push the latter back—why, we do not understand. Recent experiments by one of his students with glycerine in a Lahmeyer tester showed that the torque was of the order calculated from the viscosity; that, of course, was one of Mr. Archbutt's cases.

Mr. B. W. Hardy, Sec.R.S., who had not submitted a paper, also spoke chiefly from the chemical standpoint, emphasising the importance of surface energy. Several speakers had referred to his recent articles on Static Friction and Lubricating Properties and on the Spreading of Fluids on Glass, in the *Philosophical Magazine* of July last. Some of the points which he mentioned last Friday were novel. Cleaned surfaces would in general not slide over one another. Plotting the static friction of several series of compounds, the fatty acids in the first instance, as ordinate against increasing molecular weight, he found that the acetic, propionic, valeric, . . . stearic acids all fell on a regular descending curve; formic acid, the first member of the series, was at the upper end of the same curve, but on the solid friction side. Similarly the static friction of ammonia and substituted derivatives, trimethylamine and tripropylamine, were 0·36, 0·30 and 0·26; a series of alcohols again gave a descending series of friction values. The mixing of substances of high and low lubricating powers might have widely differing effects, and it was hence advisable, Mr. Hardy insisted, to clear up the chemical problems before going further. The details were extraordinarily complex, and all mechanical complication should be avoided for the present. To exemplify the complexity Mr. Hardy mentioned that water was not a lubricant for glass, but an excellent lubricant for ebonite on ebonite, and a fair one for bismuth on bismuth. Sulphuric acid was a good lubricant for glass and was very difficult to wipe off a glass surface; tap water and drying in air did not remove the sulphuric acid. Soap lubricated glass; the lubricating value disappeared when the glass was washed with ether, but reappeared on drying the glass.

Mr. J. E. Southcombe, of Birkenhead, next called upon, said that he had made a great many experiments in conjunction with Mr. Henry West, particularly with the object of finding out in what respect the fatty oils differed from mineral oils. But he first submitted some general considerations. If we imagined an elongated drop of mercury between the journal and its bearing, the end faces of the drop would be convex and the mercury would be pulled out of the bearing; in the case of water the faces would be concave, and the pull would be in the opposite direction, that of the rotation; in the latter case, which was also that of oil, the surface tension would lift the shaft in its bearing. In order to study the capillarity phenomena, they had used a pipette, the lower part of which was bent upward; the pipette was filled with oil, its lower end submerged under water, and the number of drops was counted which rose from the pipette in the water. In the case of various mineral oils the number of drops per unit time was, under certain conditions, always about 100, while the numbers ranged from 150 to 180 in the case of fatty oils; but by adding a little fatty acid to the mineral oil, the number 100 was brought up to 170. Some

of these results had been confirmed by Professor Lewis. We could not follow Mr. Southcombe's lengthy arguments as to the connection between these experiments and friction of solid surfaces. There was always some fine surface film, possibly of oxide; the fatty acid might enable the oil to spread; where chemical action between the oil and the solid occurred, the surface tension would fall to zero, and if the lubricant used were a pure hydrocarbon, devoid of chemical action, we wanted some substance which could be adsorbed. But Mr. Southcombe did not agree with Mr. Hardy that the phenomena should be studied apart from the disturbing mechanical influences, since lubricants were not used under ideal conditions.

Mr. H. Medway Martin, also a member of the Lubrication Committee, said that he had wished to raise the question: What is lubrication? But he was asked to be brief. He considered with Reynolds that in all, even imperfect lubrication (at any rate, fluid lubrication) the solid surfaces were separated by a film of the lubricant. The mechanism was always the same, and what happened was that when very high shearing stresses were reached, with imperfect lubrication, the lubricant failed to adhere, slip occurred and lubrication broke down. With a good lubricant adhering to the surface, the journal was able to drag in the supply necessary to maintain the film intact. But it was not merely a question of adhesion; other properties were concerned. Further references to Mr. Martin's characterisation of the problem from the standpoint of the engineer will be found in our article on page 755 of the present issue.

Mr. Edwin Edser, the last speaker, dwelt on the connection between the phenomena of lubrication and of ore flotation, on which we commented last week. Surface tension and energy, surface films and adsorption obviously affect both series of phenomena; but Mr. Edser seemed rather to attribute too much exclusive importance to adhesion in lubrication.

We may perhaps add one remark to our comments made elsewhere. It is rather striking that the application of the theory of surface affinity to lubrication problems should come so late as to be coupled with Langmuir's papers—undoubtedly of high value—contributed to the American Chemical Society in 1916. For the peculiar character of the surface layers of solids had long been recognised, and such considerations had in particular been applied to the consideration of crystallisation, solution and colloidal phenomena. A case in point is the precipitation of radium sulphate together with barium sulphate; there is no question of ordinary chemical affinity.

NOTES.

The Economy of the Heavy-Oil Marine Engine.

An interesting statement on the economy of the marine internal-combustion engine was made by Sir James McKechnie at the launch, on November 25, at the Naval Construction Works, Barrow-in-Furness, of Messrs. Vickers, Limited, of a large oil-tank steamer for the Anglo-American Oil Company. The vessel in question, the Narrangansett, has a displacement of 14,000 tons, and a deadweight capacity of 10,500 tons, and a bunker capacity of 733 tons. Her length is 425 ft. and breadth 56 ft. The four sets of engines on two shafts, are to be of the six-cylinder Vickers heavy oil marine type with cylinders 24½ in. in diameter, and 39-in. stroke. The brake horse-power will be 2,500. The vessel is designed to carry normally 9,420 tons of oil cargo and 510 tons for engine fuel. The provision of heavy-oil engines is calculated to lead to considerable economies. This is the first vessel to be so provided in the Anglo-American Oil Company's fleet. It may be pointed out that if we take as the consumption for such an engine about 0·45 per shaft horse-power hour, we get a thermal efficiency of about 32 per cent. For oil-fired steam engine plant using about 1·2 lb., the efficiency is about 11·8 per cent., and for coal-fired plant using 1·8 lb. of coal per shaft horse-power hour, it is about 10·5 per cent. Allowing for losses in propulsion these efficiency figures are reduced to 17 per cent., 6·25 per cent., and 5·56 per cent. for overall thermal efficiency of the three types of installation. The overall consumption is rather greater than the figures above, in which only the main engine is taken into account. If we take ·55 lb., 1·30 lb., and 2·00 lb. as typical overall figures for the three classes of installation for a vessel of the Narrangansett type, and 150*s.* as the price of oil, and 110*s.* as the price of coal per ton, the total cost for fuel on a 40-day voyage would work out, approximately, as 4,440*l.* for the heavy-oil-engined ship; 10,500*l.* for the same vessel fitted with oil-fired steam plant; and 11,800*l.* for coal-fired steam installation. The first shows a saving of 7,360*l.* over the latter, which can be applied to a reduction of the freight rate. On a boat of the size in question, spread over 9,420 tons, Sir James pointed out that this is equivalent to a reduction of 15*s.* 8*d.* per ton of cargo. It will be admitted that this is a very appreciable figure. The cargo pumps are duplicated, each having a capacity of 200 tons of oil per hour.

Asymmetric Filtration through Porous Walls.

While experimenting during the war with apparatus which would indicate the approach of poison gases, L. Benoist, of the Bureau des Poids et Mesures (*Comptes Rendus*, 168, page 1320), tried selective diffusion through conical pores after the manner of the Venturi effect. In the Venturi meter there is a preferential flow of liquid in one direction, and it occurred to Benoist to investigate whether it would be possible to obtain plates of earthenware and similar materials the pores of which would widen out in a continuous manner from the one face to the other. The technical difficulties of preparing slabs of regularly-increasing porosity proved too great. He therefore superposed plates of three different porosities $P_1 = 0{\cdot}30$, $P_2 = 0{\cdot}23$, $P_3 = 0{\cdot}18$, the P indicating the ratio of the volume of the pores to the total solid volume. Observing the flow of water through such composite slabs at the same initial pressure in different directions, he found that the rate of flow was greater in the direction P_3 to P_1 than in the opposite direction. The difference was small, however, the ratio found being 1·27 : 1, and though Benoist speaks of various possible technical applications of this preferential flow, he does not make any definite suggestion.

Awards to Inventors of the Tanks.

On Tuesday, the 27th ult., the Royal Commission on Awards to Inventors issued its recommendations with regard to claims regarding the invention and development of Tanks. The awards have been governed by the general principle that work coming within the scope of official duties does not entitle the claimant to special remuneration. This ruling has resulted in the dismissal of the claims of Commodore Sueter, Lieutenant-Colonel Boothby and Major Hetherington. It is further decided that though these officers are due a great deal of credit for the work they did in assisting the development of the idea, there was no specific invention on the part of either of them. The latter remark is also applied to the case of Colonel Crompton and Mr. Le Gros, who acted as consulting engineers to the D.N.C. Committee. Although they supplied a great deal of valuable data which was made use of in working out the invention, the Commission has decided that they did not invent special features and that the remuneration they received must be considered to cover their claim. The claim of Major-General Swinton is allowed in that he brought forward in 1914 the idea of a machine-gun destroyer of the general character of a tank, and in 1915 specified the necessary characteristics of such a weapon. An award of 1,000*l.* is recommended in this case. The claims of Mr. Macfie and Mr. Nesfield are also allowed. In this case the Commission consider that the ideas put forward were of value, but it has not been conclusively shown that they were communicated directly or indirectly to those responsible for the design of the tanks. A sum of 500*l.* is allowed to each of these two inventors. Sir E. Tennyson d'Eyncourt's claim is allowed to the extent of an award of 1,000*l.*, though it is pointed out that while he was acting outside his duties as Director of Naval Construction, he was within them as chairman of the D.N.C. Committee, and that mobility rather than armament was the chief invention of the tanks. The main award is recommended in the case of Sir William Tritton and Major Wilson, although allowance had to be made for the latter's official position. That the original tanks as produced by these two engineers were not altogether successful appeared to be due to the fact that the conditions under which they were used in war were far more trying than those imposed on the designers by the Government when ordering them. A sum of 15,000*l.* is jointly awarded to these two inventors. The claim of Mr. L. E. de Mole, of having anticipated the invention in 1912, has been disallowed, as the inventor was unable to advance proof of any connection between his work and the adoption of the tank idea by the Government. The Commission pays a tribute to Mr. Winston Churchill; it was largely due to his courage and driving force that the tank was brought into practical shape.

LITERATURE.

Commercial Russia. By William Henry Beable. With a map. London: Constable and Co., Limited. 1918. [Price 10*s.* 6*d.* net.]

The author had the advantage of spending six months in Russia in 1916, during which period he travelled over a wide area from Archangel to Odessa, with excursions beyond the Ural Mountains to the more settled portions of Siberia. His main purpose was to examine the social and commercial conditions of the country with the view of promoting the interests of the Anglo-Russian Trade Association. Armed with a slight knowledge of the language, and assisted by the invariable kindness of consuls, he learned much of the manner in which trade had been conducted in the past, and now believes himself to be in a position to counsel his countrymen as to the most judicious mode of carrying on profitable business relations in the future. As an impression of the writer's own personal experience and investigations, the book may prove interesting, but the reader must determine for himself the degree of reliability to be placed on the information drawn from miscellaneous manufacturers, merchants, agents and shopkeepers, whose experience was necessarily limited to the conditions that obtained before the Bolshevist *regime*. Whether the consequences of the revolution are to be regarded as a most appalling disaster, or as manifesting an opportunity for the free development of the true genius of Russia is at the present moment uncertain, but there is no evidence to show that the author foresaw the intensity of the upheaval that has overtaken the ordinary lines of commerce and industry, or that he is prepared with measures that can be safely followed in a country, where the continuance of the revolutionary spirit has entirely altered the potentialities of the trade problem. The leaders who control the movement may have designed, and even pigeonholed, an economic scheme that might be substituted more or less satisfactorily for that which has passed away with the old order of things, but the Russian workman, the proletariat, as he delights to call himself, is too ignorant, too short-sighted and too impatient to submit himself to the control of sound economic principles, however cunningly they may be disguised to meet his desires, or however urgently they may be needed for his welfare. Those least capable of governing wisely are masters of the industrial properties and means of transport, low productivity in the factories has been encouraged by the workmen, who will not submit themselves to indispensable discipline or follow the dictates of prudence and experience, but are bent on pursuing a suicidal course that will destroy both capital and credit. To attempt to formulate rules or to give advice concerning the conduct of business where the conditions of life are utterly abnormal is to misconceive the situation and to undertake a hopeless task.

Events move so rapidly and are seen projected on a background so distorted and misshapen, that it is unwise to place any reliance on the conclusions or recommendations of any authority. The author himself writes: "a man who knew Russia before the war does not know it now," and the same might be said of a man who knew Russia before the Bolshevist revolution. So much has become ancient history

since 1914, that we cannot gauge with certainty the attitude of the country towards ourselves. In 1916, it seemed reasonable to suppose that Britain might assume the position Germany had long enjoyed, and find in the growing development of Russian culture and increasing demands, a market for our manufactured goods, while the unworked natural resources of the country would afford an outlet for British enterprise and capital. Probably this encouraging view has retired into the background, not to be resuscitated till Russia's peaceful consolidation has been effected, and a permanent adjustment of the relations between the various nationalities and races secured. But little good can come from the attempt to fit the needs of an unknown future to the conditions of an effete past. Mr. Beable tells us more of the Zemstvos than of the Soviet rule, and the Bolshevist *regime* passes entirely without notice. If the information were more recent, if, for example, the book did not belong to that period when "the Zemstvo acted under the control, or, more accurately under the tutorship of the crown administration" (page 105), this absence of reference to the breach of continuity in settled Government might be explained by the fact, that any accommodation between the Bolshevists and the rest of Russia is impossible. The Bolshevists do not regard themselves as a Russian political party or administration, contending against local or national aims, but as a world force, acknowledging no national boundaries or patriotic ideals. The aim is not the restoration of ordered Government with all that is implied in the term, but the overthrow of the educated and propertied class, wherever they are found, by the least instructed and least capable. The struggle is recognisable elsewhere, but Russia is the world's scapegoat. It is the uncertainty of the ultimate fate of Bolshevist ambition that makes any forecast of the future impossible, and renders the discussion of minute business methods utterly futile.

In considering the commercial policy that will enable this country to defeat the schemes of Germany and place us in the position of the most-favoured nation, the author calls attention to three factors, that he maintains will militate against Germany after the war. Unfortunately, we have to consider whether these causes will be equally operative after the revolution. The first is stated to be the discriminating duties that will undoubtedly be levied against the Central Powers. There is little or no evidence of such intention, and if the Bolshevist remains in power then, as has been already intimated, his objection is against capital everywhere, and not necessarily against Germany. Further, as the author admits, the Russian tariff is in the melting-pot, and the form it will assume is uncertain. The need for revenue will probably be so great on the resumption of commerce, that custom duties will be a necessity against which the people will be powerless to struggle. The second operating cause is supposed to be Germany's inability to give long credits accompanied by great restrictions on her former successful attempts at "peaceful penetration." This assumption is unsupported, and leaves out of sight a factor of immense importance that has grown in acuteness since Mr. Beable was in the country. This is the depreciation of the currency; the world has not known such depreciation probably since the time of the French Assignats—and the effect on the course of commerce can hardly be forecasted. Business between two countries similarly situated in regard to depreciation may be easier of arrangement than between countries where the differences are more marked. Certainly it is reported, that the resumption of business relations between Finland and Germany does not present the difficulties that hamper commercial intercourse between Finland and England. The third factor is founded upon the supposed unwillingness of the Russians to accept German goods in consequence of the ill-feeling created during the war. This seems as unsubstantial as the others, and to offer little ground for comfort or hope. Necessity will outweigh sentiment. The desire to purchase in the cheapest market will overcome any distaste to the source of production, and much of the traffic will be in the hands of the Jews, who have suffered as much from their neighbours as from the foreigner.

A note of greater potency, and one that deserves to be heard, is struck, when the author enlarges on the probable effects of the competition that Japan and the United States are prepared to offer. These two countries, the one by the industry of its inhabitants, and the other by the extent of its resources, constitute a serious menace to our efforts, fettered as we are by our inelastic habits, indifference, and *laissez faire*. Each nation has had considerable experience in ministering to the needs of the wealthy, or in creating new and unsuspected wants among Russia's stagnant peasantry. A point which might be discussed with advantage is the adoption of means that would prevent ourselves being forestalled by the well-equipped and energetic nations already in the field. It would be safer to follow and improve on their methods, than to revive the discredited and effete policy of a bankrupt nation. The evolution of methods based on imperfect knowledge and untried by experience is not without danger, for no uniform plan of treatment is suitable to so wide a territory as Russia, harbouring many nationalities, varying in habits, in language and development. The author has had ample opportunity of noting the futility of appointing agents to represent manufacturing industries throughout the entire country, and of the necessity of recognising differences of temperament, manners and perhaps national jealousy. The late Imperial Government fostered these differences. *Divide et impera* is a motto that was fully appreciated by the astute, but selfish, brains that attempted to buttress a falling dynasty.

In looking to the future assets and potential wealth of the country, the author treads a sure path and one in which he will be followed with satisfaction. That Russia is rich in minerals is a commonplace, but here is given some estimate of the quantity, the nature of the deposit, the position in relation to the railways and ports, and the opportunities for exploiting the iron and coal, the copper and manganese, the silver and platinum, and many others by which the country is enriched. The known coal measures are second only to those of the United States, and unsuspected coalfields may yet be found in the untravelled parts of Siberia. But from the coal actually in sight, with improved ways of communication, both as regards railways and harbours on the Black Sea, the coal supplies of Russia should form a sound basis upon which may be developed expanding iron, steel, and other industries.

The iron resources tell a tale of neglected opportunities in the past, though before the war the country was becoming more alive to their importance. The undeveloped mines are an idnex of the potential wealth of the country, just as the production indicates its energy or its lethargy. The South of Russia claims a dominating position in the iron supply, but Central and North Russia each contribute an important quota. The mineral resources of the country are enormous, but the rate of productiveness has been in an inverse ratio to the quantity. While Russia, energetically directed, might have supplied the world, actually she has been unable to satisfy her own necessities. She has been obliged to import 14·2 per cent. of the coal required for home consumption and large quantities of lead, zinc, copper, salt, &c., have to be added to her own production. A great part of the minerals that are extracted and utilised are the result of British capital and enterprise working through Anglo-Russian companies.

BOOKS RECEIVED.

Guida Pratica del Meccanico Moderno. ARTURO MASSEUZ. Milan: Ulrico Hoepli. [Price 9·50 lire.]

Storage Battery Practice. By ROBERT RANKIN, B.Sc. London: Sir Isaac Pitman and Sons, Limited. [Price 7s. 6d. net.]

The Cheap Cottage and Small House, a Manual of Economical Building. By GORDON ALLEN. Sixth Edition, revised and enlarged. London: B. T. Batsford, Limited. [Price 8s. 6d. net.]

Traité de Mécanique Rationnelle. Par PAUL APPELL. *Quatrième Edition, entièrement refondue.* Tome Premiere. *Statique.—Dynamique du Point.* Paris: Gauthier-Villars et Cie. [Price 36 francs.]

Sells' World's Press, the Handbook of the Fourth Estate. Founded by HENRY SELL. The thirty-fifth—1919—edition. Edited by E. T. BROWN. London: Sell's, Limited. [Price 10s. 6d. net.]

Model Making. Edited by RAYMOND FRANCIS YATES. London: Hodder and Stoughton. [Price 15s. net.]

Catalogue of the Watt Centenary Exhibition Science Museum, South Kensington. London: H.M. Stationery Office. [Price 1s. net.]

Reid's Handy Colliery Guide and Directory for the Counties of Northumberland, Durham and Yorkshire. Newcastle-on-Tyne: Andrew Reid and Co., Limited. [Price 2s. 6d.]

Sewage Disposal. By LEONARD P. KINNICUTT, C. E. A. WINSLOW and R. WINTHROP PRATT. Second edition, re-written. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 10s. 6d. net.]

Popular Handbook for Cement and Concrete Users. By MYRON H. LEWIS and ALBERT H. CHANDLER. Second edition. London: Hodder and Stoughton. [Price 15s. net.]

"Financial Times" Investment Account Book. Compiled by H. A. RANDALL, F.C.I.S. London: "The Financial Times, Limited. [Price 8s. 6d. net.]

All the World's Aircraft. Founded by the late FRED. T JANE. Edited and compiled by C. G. GRAY. London: Sampson Low, Marston and Co., Limited. [Price 42s. net.]

Indicator Diagrams, Steam and Oil Engines for Marine Engineers, fully illustrated and explained. By W. C. MCGIBBON, M.I.M.E. Fifth edition. Glasgow: James Munro and Co., Limited. [Price 12s. 6d. net.]

Marine Oil Engines, their Construction, Management and Maintenance. By W. D. MARTIN, M.I.E.S. Glasgow: James Munro and Co., Limited. [Price 7s. 6d. net.]

Catalogue of the Mechanical Engineering Collection in the Science Museum, South Kensington, with descriptive and historical notes. Sixth edition, with a supplement containing illustrations. London: His Majesty's Stationery Office. [Price 2s. 6d.]

Engineering Education. Essays for English selected and edited by RAY PALMER BAKER, M.A., PH.D. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 6s. net.]

Gas and Oil Engine Operation, including Gas Producers and Petrol Engines. By J. OKILL, M.I.A.E. London: Sir Isaac Pitman and Sons, Limited. [Price 5s. net.]

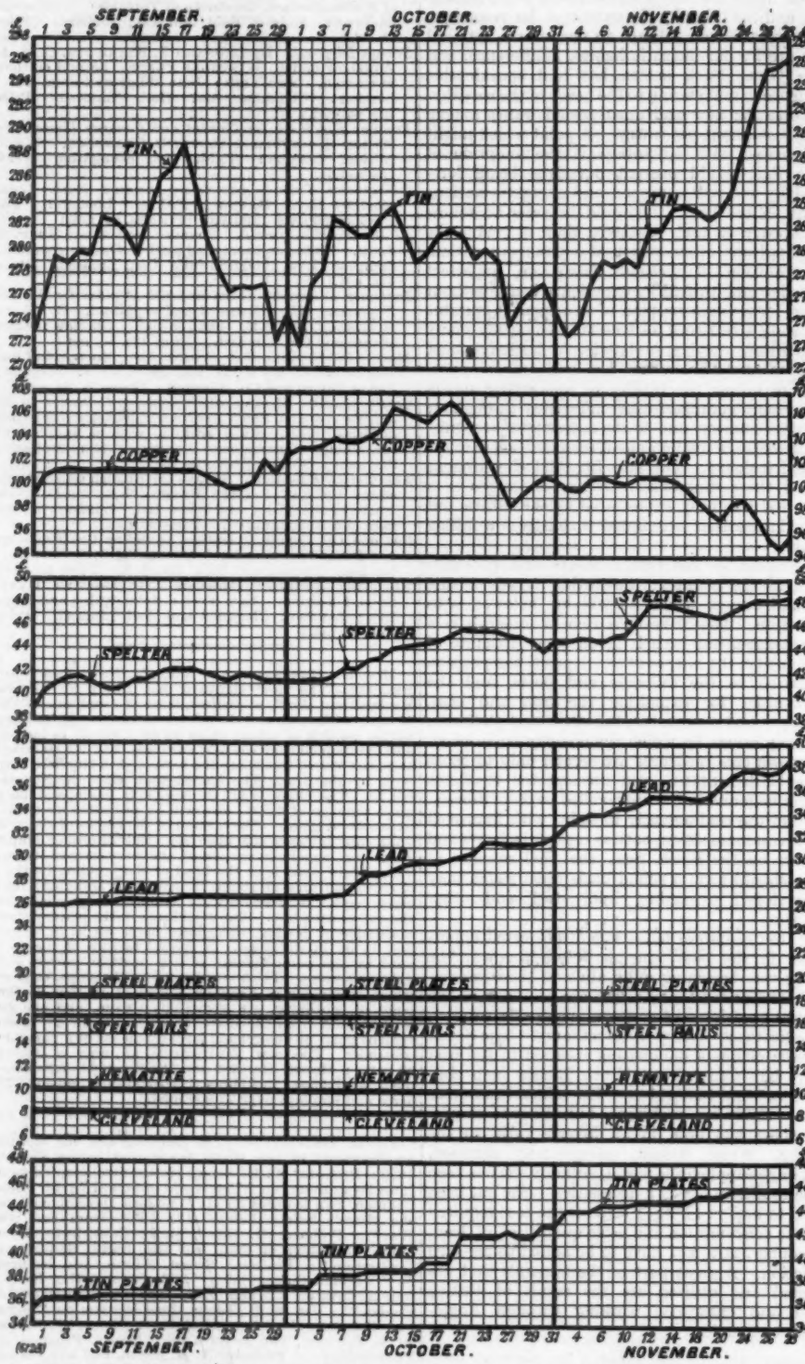
Automatic Sprinkler Protection.—By GORHAM DANA. Second Edition. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 17s. 6d. net.]

MESSRS. HARLAND AND WOLFF'S NEW SHIPYARD, BELFAST.—The new shipyard put down by Messrs. Harland and Wolff, at Belfast, is on the east side of the Musgrave Channel, and the scheme comprises six building berths capable of taking ships up to 1,000 ft. in length. The first launch from the new yard was that of a standard ship, the Maine, this being the forty-eighth standard ship built by the firm. The launch took place on November 25. The Maine is 412 ft. long, 55 ft. beam, and has a gross tonnage of 6,500; she will be propelled by triple-expansion engines. The bottom of the berths of the new yard face towards the open sea, this affording ample space for launching vessels of the very largest types. The platers' shed is at the head of the building berths; it covers an area of about 7½ acres and is divided into eight bays. A stockyard for material is provided at the end of each bay. The machinery in the platers' shed is capable of dealing with plates up to 40 ft. in length and 1½ in. in thickness. A special feature of the new yard is the completeness of the electric power and lighting system. The tower cranes on the ships, each of which is capable of handling a load of 10 tons at the point of cantilever, are electrically driven, and can be worked both from the driver's cab and from any convenient point on the ground level by means of a portable controller. The new yard covers an area of about 83 acres; Messrs. Harland and Wolff's whole establishment at Belfast, including this extension, covers 220 acres and employs over 22,000 men.

ROYAL INSTITUTION.—The following are the lecture arrangements at the Royal Institution before Easter, 1920: Professor W. H. Bragg, six lectures adapted to a juvenile auditory, on "The World of Sound"; Sir John Cadman, two lectures on (1) "Modern Development of the Miner's Safety Lamp," (2) "Petroleum and the War"; Professor G. Elliot Smith, three lectures on "The Evolution of Man and the Early History of Civilisation"; Professor Ernest Wilson, two lectures on "Magnetic Susceptibility"; Professor Arthur Keith, four lectures on "British Ethnology: The Invaders of England"; Dr. R. R. Terry, three lectures on "Byrd and Palestrina," with musical illustrations; Professor A. E. Conrady, two lectures on "Recent Progress in Photography"; Professor A. H. Smith, two lectures on "Illustrations of Ancient Greek and Roman Life in the British Museum"; Lieutenant-Colonel E. Gold, D.S.O., two lectures on "The Upper Air"; Mr. Stephen Graham, two lectures on (1) "The Spirit of America after the War," (2) "The Hope for Russia"; Professor Alfred Noyes, two lectures on (1) "The Anglo-American Bond of Literature," (2) "Aspects of Modern Poetry"; Sir F. Watson Dyson, Astronomer Royal, three lectures on "The Astronomical Evidence Bearing on Einstein's Theory of Gravitation"; and Professor Sir J. J. Thomson, six lectures on "Positive Rays." The Friday evening discourses will begin on Friday, January 16, at 9 o'clock, when Professor Sir James Dewar will deliver a discourse on "Low Temperature Studies." Succeeding discourses will probably be given by the Hon. Sir C. A. Parsons, Mr. S. G. Brown, Professor W. M. Bayliss, Dr. E. J. Russell, Mr. W. B. Hardy, The Hon. J. W. Fortescue, Professor J. A. Fleming, Mr. E. McCurdy, Professor Sir J. J. Thomson and other gentlemen.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig iron. The prices given, in the case of steel plates, are for ship, bridge, and tank qualities, and those for steel rails are for heavy sections. The pig iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

GERMAN STOCKS HELD IN SWITZERLAND.—The accumulation by the Germans of stocks in Switzerland was a constant source of interest during the war, and, according to a statement published recently in the *St. Galler Tagblatt*, it would appear that a certain portion of the cotton which had been stored in Switzerland for German account, and could not be sent out of the country during the war in accordance with the regulations of the S.S.S., has now been forwarded across Lake Constance to Bavaria, to the spinning-mills of Kolbermoos, near Rosenheim, and to those of Stadtbach in Augsburg. The latter mills received no less than 3,300 bales. These goods, which were bought at very low prices, will ensure quite abnormal profits to both the mills in question.

A TEST OF WATERTIGHT BULKHEADS FOR SHIP SUBDIVISION.*

By ARCHIBALD HOGG, *Associate Member*.

IN January, 1915, an interesting test was made on two types of watertight bulkhead. One of these was the first flat plate bulkhead to be constructed to the recommendations of the late Bulkhead Committee. The other contained new features which required testing in order to provide the necessary information asked for by the Classification Societies before their "satisfied" approval could be given.

PART I.

In order to make the test conditions as near as possible to those in an actual cargo ship, a portion of a single decker with double bottom was built. It was about 21 ft. long, 45 ft. beam and 30 ft. deep at the middle line. The bulkheads were placed 7 ft. 6 in. apart in the middle of the length. Each bulkhead measured 45 ft. beam and 26 ft. 9 in. high at middle line; the deck was rounded up 11¼ in. It will be noted that the height of the bulkheads is about 30 in. higher than the limit given in the table of the new Rules. It was considered that more valuable data would be thus obtained than could be got from bulkheads of small height.

The ordinary flat bulkhead was plated in horizontal strakes of thicknesses varying from 0·26-in. at deck to 0·36-in. at foot in way of a part with 30-in. spacing of stiffeners; about two-thirds of the breadth from one side was stiffened with bulb angles 12-in. by 3½-in. by 0·52-in. spaced 30-in. centres and attached top and bottom with flanged bracket plates 36-in. by 36-in. by 0·44-in., having nine ¾-in. rivets each way of the bracket (see Fig. 1). The other one-third of the bulkhead was stiffened with channels 15-in. by 4-in. by 4-in. by 0·625-in. webs and 0·625-in. flanges, spaced 36-in. centres and attached top and bottom with single lugs 7 in. by 7 in., having eight ¾-in. rivets on each flange (see Fig. 2). The boundary connections were of single angles 3½ in. by 3½ in. on the deck and sides and 5 in. by 5 in. on the tank top.

For test, the hold was filled with water, the filling being stopped at several stages and the deflections carefully noted at several positions acrosswise and over full height at each stage. After being filled to deck for first time the hold was emptied and the condition of the bulkhead as to permanent deflection noted. The space was then refilled and a head of water run up ultimately to 8 ft. 6 in. above the deck, the filling being stopped at two stages between this maximum and the deck. The hold was again emptied and the condition noted. A greater head would have been added but, at the 8-ft. 6-in. head the yielding of the deck, owing to its being stopped short and not continuous, made more severe test impracticable.

In the case of the flat bulkhead, the whole bulkhead bellied out in a fairly circular shaped curve from side to side, and also in the vertical direction except for a straightening towards the top and bottom caused by the restraint in the stiffener end connections, though only at the foot was there a slight reverse to the curve. The maximum deflection was at the middle point of the whole bulkhead.

There were numerous petty "weeps" along the seams of the flat plating and especially at the higher heads of water, under which small leaks also took place at the foot where rivets were slightly slackened.

When the head of water reached 5 ft. above the deck, the bottom brackets began to show a tripping movement and at 8-ft. 6-in. head half of the brackets (those nearest the middle line) were distorted showing the toes falling away from the connecting lugs and the vertical flanges of the lugs bevelled somewhat. At the 8-ft. 6-in. head a good number of the rivets at the foot, in brackets and boundary bar, showed a slackening and strain. In the channel lugs the slackening of rivets showed in the horizontal flanges on tank top in the row of rivets next to the stiffener webs.

While the whole flat plating bellied out in a fair curve from side to side, the curve was broken up into a series of curves between each pair of stiffeners—with the hold filled this local deflection was ½ in. at the 30-in. spacing and about ¼ in. at the 36-in. spacing.

When the hold was filled for the first time, the maximum deflection was 1·85 in., and on being emptied a maximum deflection of 0·07 in. or say $\frac{1}{14}$-in., was found. When the 8 ft. 6-in. head was reached, the maximum deflection was 6·90 in., and on being emptied a maximum deflection of 4·5 in. was found. These deflections at the emptied conditions show the permanent "set" which had been given by the load applied. The permanent set began when the first filling reached three-quarters of the height of the bulkhead. It should be noted that had the deck been continued for a greater distance from the bulkhead, the deflections might have been slightly less.

In the bulb-angle stiffened portion, the stiffener girder section of this flat bulkhead includes the bulb angle plus the rivets in the seam lap of the plating for one stiffener space (the rivets are taken because their area is less than that of the plating): the S.M. = 30·65, the M.I. = 253, the greatest distance from the neutral axis = 8·42 in.

The 1·85-in. deflection with full hold corresponds to a maximum calculated stretch of fresh steel on the face of the bulb of at least 0·00115 in. per inch, which multiplied by 13,000 shows a stress of 14·90 tons per square inch (the actual stretch was 0·00208 in.). As this stress is above the elastic limit it follows that the permanent set noted must have taken place after a given time; also that given sufficient time the continued application of the same load would ultimately cause the bulkhead to

* Paper read before the North-East Coast Institution of Engineers and Shipbuilders, Friday, November 28, 1919.

fail, although it would most likely hold long enough to bring the vessel safely into port. Should a hold be flooded at sea the load on the bulkhead would certainly be considerably heavier than was put on it at the test. The ship has to be brought to port either by her own power or by a tug and most likely there would be some "sea" on, so that the water in the hold would have motion and its great mass would be heaved repeatedly against the bulkhead. Thus the safe return may depend somewhat on the weather. Should the ship be then safely brought to port, the bulkhead would be left with a considerable permanent set, and it would require strengthening to make it of the original strength.

As showing that a permanent "set" should be expected after filling the hold, assume the stiffener girder to be fixed ended and find what would be the stress near half height, thus:—the load per panel is 25·6 tons, the

B.M. near half height $= \frac{25{\cdot}6 \times 26{\cdot}75 \times 12}{12} \times 0{\cdot}535$

= 366-in. tons, the stress being $366 \div 30{\cdot}65 = 11{\cdot}95$ tons. However, the deck is a soft foundation and it yields so that the girder is not fixed-ended and becomes more like one fix-ended at one end and support-ended at the other, in which case the B.M. near half height would be about $\frac{25{\cdot}6 \times 26{\cdot}75 \times 12}{8} \times 0{\cdot}52 = 445$-in. tons, the stress being $445 \div 30{\cdot}65 = 14{\cdot}52$ tons. These figures assume no relief from the diaphragm value of the whole bulkhead, but then the actual 1·85-in. deflection took place while this value was doing its part. It is difficult to see at this stage that it had any value in relieving the stiffeners at the middle line even though the test bulkhead was a narrow one being only 45 ft. against 50 ft. to 52 ft. of many actual ships. When the head of water was 8 ft. 6 in. above the deck, the maximum deflection was 6·9 in., the actual stretch of steel on the face of the bulb was 0·0074 in., showing a stress of about 19 tons per square inch.

The curving of the bulkhead from side to side would indicate a pulling from each side by the plating. This prevents the side stiffeners from deflecting to their fullest, and thereby the plating takes some responsibility on itself. The load thus taken off the stiffeners will be roughly $\frac{26{\cdot}5 \times 17{\cdot}5 \times 13{\cdot}5}{(35 \times 3)} = 600$ tons, or say $2\frac{1}{4}$ tons per foot of the height average.

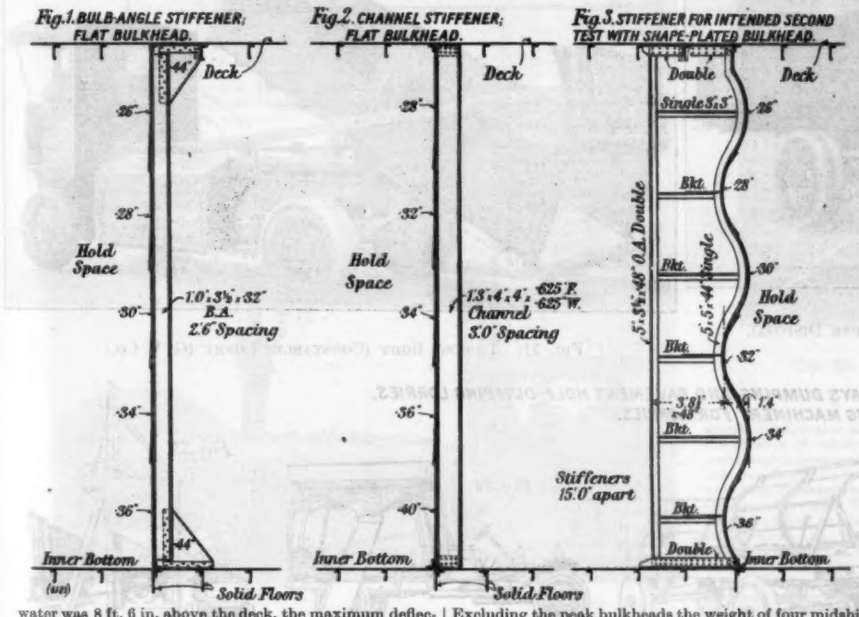
The plating is doing an important local work between stiffeners, and as its thickness is tapering from 0·26 in. to 0·36 in., a piece at half height will give a fair indication of the stresses over the whole height. Take a strip between the shell and the nearest stiffener, 15 in. broad, this would have four rivet holes in the shell bar countersunk, deducting $4 \times 0{\cdot}937$ in. = 3·75 in., leaving 11·25 in. of metal, the thickness is 0·30 in., the effective S.M. and M.I. of the section of this strip may be taken at:—S.M. = 0·197 and M.I. = 0·0295. The local load is $2{\cdot}5 \times 1{\cdot}25 \times 13{\cdot}5 \div 35 = 1{\cdot}205$ tons. The greatest B.M. $= \frac{1{\cdot}205 \times 2{\cdot}5 \times 12}{12} = 3{\cdot}015$ and the greatest stress $= 3{\cdot}015 \div 0{\cdot}197 = 15{\cdot}35$ tons per square inch. The above pull by the plating will be about 3 tons on this 15-in. strip. This should relieve the plating of some of the 15·35 tons stress. It is evident that the strength of the plating harmonises with that of the stiffeners, and should the hold be flooded at sea, the plating will have lost some of its strength and this should be compensated when renewing the strength of the bulkhead.

No sign of strain was to be seen in the bracket connections when the hold was filled, beyond the fact that the top of the bottom brackets a movement or deflection of the stiffener took place amounting to 0·45 in. and at the bottom of the top bracket a movement of 0·63 in. The latter is easily accounted for by the yielding of the deck, the former is not so easy; the toes of the bottom brackets rested on a solid floor in the double bottom so that the movement at the foot can only be accounted for by the addition of a few slight movements, say:—(*a*) tank top lifting at the boundary bar; (*b*) toes dropping slightly due to slight change in floor plate; (*c*) a yielding of the bracket itself at the connecting lug and at the stiffener; and (*d*) a movement or crushing of the metal at the rivets, i.e., in the stiffener, in the bracket, in the connecting lug and in the rivets.

Where channel stiffeners were applied, they deflected practically to an arc of a circle when the hold was filled. The girder section in this part has its neutral axis at 9·74 in. from the face of the channel. These stiffeners proved to be slightly stiffer than the bulb angles, their maximum deflection being 1·60 in. against 1·85 in. of the bulb angle. The corresponding maximum stretch of fresh steel in the channel face was 0·00116 in., the actual stretch was 0·00218 in., so that the stress was 15·10 tons per square inch. The two types of stiffeners are therefore very near one another as regards their strength. The movements at the ends of the channels were pretty similar to those of the bulb angles though to a less degree, due to their greater depth.

It is perfectly clear that the latest watertight flat bulkhead for ship subdivision is a very neatly designed one which could only have been arrived at after an actual test of a full-sized bulkhead; for the full hold condition its strength could not well be less for tightness.

The bulkhead has a most important duty to perform, perhaps only once in the life of a ship and perhaps never: hence a desire to avoid continually carrying a weight of metal no doubt had its influence in keeping down the weight of steel used in building subdivision bulkheads.



Excluding the peak bulkheads the weight of four midship bulkheads in a medium-sized six-bulkheaded vessel will be about 80 tons. The weight of one bulkhead, 52 ft. 6 in. × 26 ft. 9 in., with flat plating to Rule requirements is made up as follows:—

	Tons net.
Boundary bars...	0·60
Plating	8·05
Stiffeners	9·95
Rivet heads	0·65
Total	19·25

The stiffeners are the heaviest item and are very nearly 25 per cent. more than the plating. Channel stiffener arrangement would be practically the same weight as bulb angle.

It is absolutely correct in principle that all unnecessary weight of steel should be avoided. At the same time it is absolutely correct in principle that all parts should have the requisite reliable strength. Has the latest flat bulkhead for subdivision a strength which can be said to fulfil these two conditions? The test results, it will be noted, were got from steel at its best, newly erected, with designed thicknesses. Why not make the bulkhead so that when it has brought the ship to port it will have no permanent set left in it? This could be done with the addition of 2 to 3 tons of steel per bulkhead, 52 ft. 6 in. by 26 ft. 9 in., or say 10 tons in the whole ship, and what is that in a ship with about 2,000 tons in her structure?

PART II.

The second bulkhead at the above test was of a different construction, being composed of only two stiffeners plus the plating, the latter being so disposed that it could itself support the local loads between the widely-spaced stiffeners. This test bulkhead was built "on the weak side" in order that all possible developments would be ascertained, and the results of the test proved how neatly this had been done. The stiffeners were designed on a "fixed-ended" basis, the centre portion being only 27 in. deep. Thus when the hold was filled the deck yielded so that the stiffeners deflected ½ in. and the small thin web plate buckled slightly. These were subsequently stiffened by riveting angle bars across them and the filling proceeded till a head of 8 ft. 8 in. above the deck was reached, when a further yielding of the short deck stopped the test. The deflection at the last recorded head, 2 ft. 6 in. above deck, was 1·15 in. At no point during the whole test was there any leakage beyond a few slight weeps.

It was intended to build a new bulkhead based upon the data obtained from this test, but this was prevented by war conditions. However, a number of ships have been fitted with the new bulkhead, and in two ships this bulkhead has actually been thoroughly tested and proved to be most efficient by the flooding of the hold after being torpedoed at sea. The ships were in ballast trim and the water reached some feet above the top of the hold bulkhead, the ships having been safely brought into port. No sign of straining could be seen on the bulkheads and nothing was done to them.

The new bulkhead for the intended second test would have had two stiffeners, the section being made up of a web plate 44½ in. × 0·48 in., single connecting angle 5 in. × 5 in. × 0·44 in., and double face angles 5 in. × 3½ in. × 0·48 in. (see Fig. 3). Allowing only a small portion of the bulkhead plating as part of the girder section, the S.M. = 466, the M.I. = 10,750, with neutral axis 23·06 in. from the face of the web. When the hold is full, the deflection should be about 0·167 in. (roughly speaking this is eight times stiffer than the flat bulkhead and thus should give better support to the hull), the maximum stretch of steel at half height about 0·000529 in., the stress being about 6·87 tons per square inch. The B.M. near half height, assuming one end "fixed" and the other "supported" is $\frac{26{\cdot}5 \times 15 \times 13{\cdot}62}{35} \times \frac{318}{8} \times 0{\cdot}52 = 3200$, the stress being 6·86 tons. If you assume only "support" ends, the B.M. half height $= \frac{155 \times 318}{8} = 6160$, so that the stress would be 13·2 tons. The foot of the web is 33 in. broad and is connected by 30 ¾-in. rivets in double shear; the S.M. about an axis at the boundary bar is about 640. The sectional area of the web plate at foot is 25·4 square inches, making a reaction of 3½ tons per square inch.

The plating would be formed into a series of deep girders, at least 16 in. deep, and continuous from side to side in thickness, exactly the same as used for the ordinary flat bulkhead, viz.: 0·26 in. to 0·36 in. The plating is curved in arcs of a circle (they may be trough shaped with flanged corners), reversed and forming a large corrugation. At half height, a strip, or half girder, would be 48 in. wide and 16 in. deep, having S.M. = 57 and M.I. 466. The local load is 23 tons. The B.M. is $\frac{23 \times 15 \times 12}{12} = 345$, the stress being 6·05 tons per square inch. The local deflection might be taken at $\frac{23 \times 180^3}{350 \times 13000 \times 466} = 0{\cdot}064$ in.

The above is the bulkhead put forward as the equivalent in strength to the Rule flat bulkhead. It is designed so that when the head of water reaches a distance above deck equal to half the height of the bulkhead the maximum deflection will equal the height divided by 330.

The advantage of this type of bulkhead lies in its light weight; four of these bulkheads, each 52 ft. 6 in. × 26 ft. 9 in., would weigh 56 tons, against 80 tons of the flat ones, each being made up as follows:—

	Tons net.
Boundary bars	0·602
Plating	8·670
Stiffeners	4·250
Rivet heads	0·358
Total	13·880

The stiffeners are only a little more than half the weight of the plating. The ordinary flat bulkhead is therefore about 40 per cent. heavier. It will be readily seen that any additional strength can be given to this type of bulkhead with but little addition to the weight. It therefore ideally fulfils the above two conditions of strength and lightness. The workmanship involved is exactly the same type as is involved in every ship in shaft tunnels and bilge plating and rather considerably easier.

AMERICANS IN SPAIN.—We read in *The Board of Trade Journal* that travellers who have visited Spain since the armistice cannot fail to have been struck by the much larger place which American interests now appear to occupy in this country, states the *Anglo-Spanish Trade Journal*, of Bilbao. The impression made by the huge scale on which the United States entered the war impressed the Spaniards to such an extent that now a great deal of the admiration which Spaniards had for certain aspects of Kultur is being transferred to the Americans. The presence of American officers and agents in every port and town, the activity displayed by American engineers in exploring and studying Spanish sources of industrial and mineral wealth, the visit of American bankers, who seem to have interviewed everybody of importance, have impressed all ranks of Spanish society and created a new current of opinion. How much of the vast schemes talked about will ever come into being it is difficult to foresee, but it is undeniable that American interests to-day seem in a more favourable position than they have ever been in the Peninsula.

THE PRESENT POSITION OF MECHANICAL ROAD TRACTION.*

By C. G. Conradi, of Derby, Member.

(*Concluded from page* 718.)

Tipping Lorries.—Unloading, as a rule, presents less difficulty than that of loading, and in the case of rough material such as sand, road metal, &c., the now familiar tipping body is the most commonly used. Examples of these are shown in Figs. 30 and 31, herewith, whilst Figs. 32, 33 and 34 show more recent variations of the same to suit particular requirements such as sideways dumping, dumping coal down pavement holes, &c. Electric tipping lorries, of which Figs. 30 and 31 are typical examples, are extremely useful for refuse disposal, coal transport and such work, the tipping gear being either hand or power-operated by a small separate electric motor. In the former of these two, the Orwell, the tipping gear is arranged with two screws of different pitch and in such a manner that during operation the body is carried to the rear at the same time as it is being tipped, whilst in the latter, G. V.-Constable, the body is moved out by a single screw until a balance is obtained and, then tipped, the power required being thereby reduced. A special feature is the method of mounting the door so that it remains in position whilst the body falls away from it and leaves a very free opening. The advantages of the "electric" for municipal and all town collection and delivery work are being rapidly recognised, and a great increase in this type is to be looked for in the near future. An electric vehicle which has been specially designed by the author for such house-to-house work is shown in Fig. 36 opposite. In this case the entrance is at the front, the driver's cab being dropped between the side members of the chassis to such an extent that only one step up is required to enable the driver to mount, considerable time and energy being thereby saved. A special "inching" or "loading" control is also provided when desired for use in refuse collection, whereby the vehicle can be steered and driven slowly from ground level, thus obviating the necessity for the driver's mounting into the driving seat for a movement of probably only a few yards between stops. This gear is "foolproof" and can instantly be put out of action to allow of ordinary driving being resumed. It has been shown for clearness at the front of the vehicle, but might be equally well used at the side. Fig. 35, above, shows the possibilities of using specially-designed unloading machinery.

Heavy goods which cannot be dealt with by tipping bodies may be lifted off by self-contained cranes, either hand or power-operated. Fig. 37, page 765, illustrates one of these which has been in use for logging and similar purposes, as fitted by the Yorkshire Motor Company. The lorry shown is one of the firm's standard 5-ton to 6-ton vehicles, capable of speeds up to 8 m.p.h. and of hauling a further load of 4 tons on a trailer when required. The crane, which is fixed behind the driver's cab, has a radius of 7 ft. 6 in. and a clearance of 5 ft. 6 in. between hook and platform. It can lift 2 tons, and is driven off the engine by friction clutch put into operation by depressing a foot lever on the driver's footplate.

An ingenious piece of apparatus which may be considered as a direct product of the war is the Wilkins truck emptier illustrated in Figs. 38 and 39, page 766. This is an adaptation of the roller-blind shutter which, as an unloading device, has the advantage that any fraction of the load can be readily dumped as desired, whilst it can also be used to facilitate loading.

Barrows.—In the loading of all heavy goods, barrows of some description are necessary, and for the actual picking up and moving of packages it is difficult to find a more efficient machine than the so-called miller's two-wheeled hand-barrow, the toe of which can be so conveniently inserted under a package and used as a lever to lift and carry the same. The capacity of such a barrow, however, is strictly limited, and if any considerable distance has to be covered it is advisable to adopt power haulage. Considerable numbers of hand-operated trucks with lifting tops and of capacities up to 15 cwt. are now in use. These are sometimes known as jack trucks, being, as the name implies, a combination of lifting jack and truck, and are made in various forms to suit individual requirements. Figs. 40 and 41, page 766, show two Hardaker trucks, the first being capable of lifting 15 cwt., whilst the second has a special U-frame designed for use with boxes arranged for dealing with quantities of small heavy parts. Where long runs obtain, electric baggage trucks carrying loads up to 2 tons or acting as tractors for trains of small trailers are useful in expediting the loading and unloading of the road vehicles, whilst for special cases they can be provided with power-operated lifting platforms and loading trays or small cranes for heavy loads. Figs. 42, 43 and 44, page 766, illustrate this type of apparatus as manufactured by the Edison Accumulator Company. A lifting platform truck operating on war material is reported to have dealt with 150 tons of material in one day, whilst trucks working on long runs with trailers regularly deal with 200 tons and upwards per week. Where there is a steady stream of standard pieces to be transported, it pays to have the trailers specially designed to suit the work, saving in time being thereby effected in packing, arranging and securing the articles.

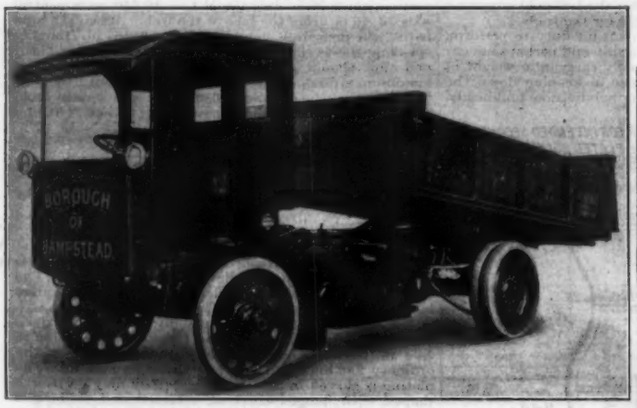


Fig. 30. Electric Tipping Lorry for Refuse Disposal (Mossay Orwell).

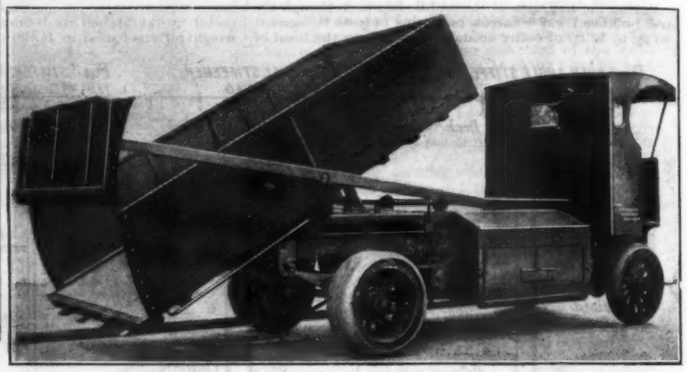


Fig. 31. Tipping Body (Constable) Lorry (G. V. Co.).

Figs. 32 to 35. TIPPING, SIDEWAYS DUMPING, AND PAVEMENT HOLE DUMPING LORRIES, ALSO UNLOADING MACHINERY FOR LORRIES.

Fig. 32.

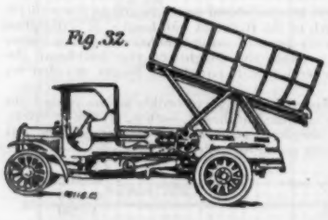


Fig. 33.

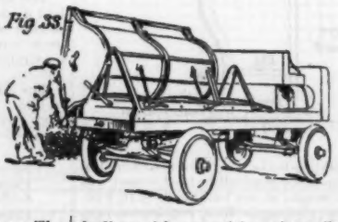


Fig. 34.

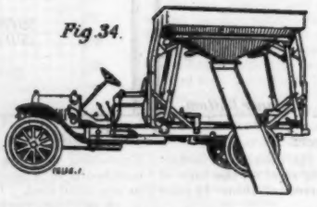
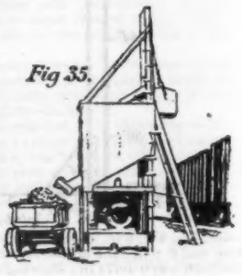


Fig. 35.



Characteristics of Motor Vehicles.

Turning now to the various types of vehicles available, it would be well to consider first their general characteristics so that one may the more readily note the fitness or otherwise of the various details of design which go to the make up of the vehicle as a whole and the fitness of that whole to fill the rôle for which it is most obviously suited. Self-propelled vehicles may be driven by steam, electricity, or internal-combustion engines using gas, petrol, or benzol, paraffin or alcohol as fuel, whilst the mixed petrol-electric system may also be noted.

Steam.—The steam vehicle for commercial work is a most reliable and useful machine, but is handicapped against universal adoption by the boiler, which does not appear capable of further improvement in the necessary direction. The boilers of such vehicles are largely of the fire-tube variety, which means that they are costly and heavy and cannot readily be designed in the smaller sizes. This, and the fact that the weight of supplies of fuel and water is considerable, no doubt account for the scarcity of "steamers" below about 3½-ton capacity, and altogether their qualifications seem to suit them best for heavy hauls at moderate speeds over comparatively long distances. "Steamers" for light passenger cars are still being turned out steadily in America, but in relatively small numbers, and not at all in this country.

Petrol.—What is popularly known as the petrol vehicle has a characteristic governed by that of the internal-combustion engine on which it depends for its power of locomotion. This motor is essentially a one-speed machine with comparatively little flexibility, and has therefore to be combined with some form of starting and speed-varying gear. The necessity for gear changing has been reduced to some extent by the fitting of excessively large engines, but only at the expense of fuel consumption, car tax (in the case of passenger cars), &c. The petrol vehicle is best suited, therefore, for work involving few stops and high speed, where starting and gear changing, with the attendant racking stresses, will be a minimum.

Electric.—The electric vehicle, on the other hand, having no change-speed gear, low maximum speed, high acceleration, no reciprocating parts, easy control in traffic, and limited radius of action, is best fitted for short-distance frequent-stop service through congested areas, although it is also very suitable and has been used as a tractor for heavy haulages.

Comparison of the Three Systems.—It will therefore be observed from a consideration of the characteristics of the various types of machines that there should be little competition between them, each having a fairly well-defined sphere of usefulness. The competition is rather between horse and motor, and even then only for short-distance work, where, in some cases, the former still has some advantages. Fig. 45 shows the relative positions of these three main classes of vehicles when their running costs, based on their nominal capacities, are compared, and it will be noticed that the "petrol" after the 3-ton point is reached, has to give place to the "steamer," whilst the latter also approaches very closely to the "electric" after 5 tons is reached. Beyond capacities of 5 tons to 6 tons it is probable that the electric would be built as a tractor with trailer or semi-trailer. The deductions to be drawn from this chart agree very well with the conclusions obtained from the consideration of the characteristics of the type of machine, and the approximate field of usefulness when the conditions are favourable to the type is shown by the solid line. The very wide range of the "electric" should be noted, and if the "petrol-electric" be admitted to this class all work, excepting where speed is a *sine qua non*, comes within its scope.

It is only in Britain, and perhaps more especially in England, that the steam vehicle has been used to any considerable extent, ample supplies of suitable fuel no doubt contributing largely to this result. The boilers, as previously indicated, are chiefly of the fire-tube variety, whilst the locomotive type predominates. The vertical boiler is believed to be in use on four makes of vehicles with satisfactory results, an example of the "Sentinel" water-tube boiler being shown in Fig. 46, page 767, which is conspicuous for its simple construction

* Paper read before the Institution of Mechanical Engineers, on Friday, November 21, 1919.

and the ease with which it can be opened up for inspection. This can be accomplished by undoing two joints and dropping the inside out entirely, Fig. 47, without disturbing any of the joints on the outer shell. The position and type of engine is a moot point in the design of steam wagons, and from the success attending both the undertype and overtype, the simple and the compound, there appears very little to choose between them all. The "Clayton," Fig. 39, page 766 (end view only shown), is an example with a compound overtype engine, whilst the "Sentinel," Fig. 46, page 767, is fitted with a double cylinder simple undertype engine. The undertype-engined vehicle no doubt comes out shorter, and therefore has some advantage from the manœuvring point of view, whilst it is also claimed in some cases that a lighter vehicle can be produced.

Steam tractors and traction engines have been improved chiefly in the direction of increased economy by the introduction of compounding, &c., whilst many of them are now fitted with rubber tyres. Fig. 48, page 767, shows an up-to-date steam tractor on rubber tyres built by Messrs. Foster and Co., of Lincoln. Such a machine is capable of developing from 14 h.p. to 20 h.p. and of hauling a gross load of from 8 tons to 10 tons up a gradient of 1 in 8. The weight in working order is about 5½ tons.

The heavier type of steam tractors, known by the generic name of "traction engines," are fitted with engines and boilers capable of developing on the larger sizes 50 h.p. to 60 h.p., and of dealing with loads up to 25 tons, whilst their weight in working order may be anything up to 16 tons.

Petrol-Engine Tractors.—One of the most powerful petrol-engine tractors is shown in Fig. 49, page 767, and is a Foster 105 brake horse-power tractor capable of hauling 30 tons to 35 tons at a speed of 5 m.p.h. The engine has a governed speed of 1,000 r.p.m. and transmits its power through worm gear to a differentially-geared cross-shaft which carries a pinion on each end, gearing into toothed rings on the road wheels. The rear road wheels are 8 ft. diameter and 2 ft. wide.

The petrol vehicle as a whole is well known and has not altered greatly in general design within recent years, although it has been improved considerably in detail design and by the use of alloy steel in construction; both of these have made for greater reliability, freedom from breakdown and reduction in weight. The greatest strides in the use of the internal-combustion engine for transport and haulage work have been made in tractor design for military and agricultural work, much of which was the outcome of necessities occasioned by the late war. Purely agricultural tractors cannot bulk largely in road transport, owing to damage which would be caused to the roads by wheels made suitable for work on the land, and the logical conclusion is that the tractors designed for work on the land should be restricted, to such work, and that the haulage of the produce on the roads be carried out by road vehicles of the ordinary type, or where badly made yards or field entrances have to be negotiated frequently, by four-wheel drive machines.

Electric Vehicles.—Electric battery vehicles, although rapidly increasing in number in this country, are not a very familiar sight in the streets, and, except to those specially interested in them, may be looked upon as a new aspirant in the field of mechanical road traction. It may be pointed out, however, that heavy electric vehicles have been in use in America for about eighteen years, many of the original vehicles being still on the road, whilst in England and on the Continent numbers have been in use for many years. In Greater New York it is understood that about 43 per cent. of the total number of vehicles used for commercial purposes are electric.

After the failure of various attempts at battery traction between 1885 and 1898 it was practically abandoned in this country, but in America, France and Germany it was continued, with the result that, especially in the former, it was soon on a fairly satisfactory basis. Great credit is due to American engineers, who slowly but surely overcame the mechanical and electrical disabilities of the lead battery and brought the alkaline cell up to the point of being a commercial success. The chassis of some of the early machines which are still running are reported as showing no deterioration whatever, which is no doubt due to the low maximum speed and absence of vibration in the driving mechanism. The advantages of the "electric" might be briefly stated thus: Cost of energy is low, and until the effect of war conditions was felt had been steadily decreasing; no power is consumed whilst at rest; can be easily controlled by unskilled labour, horse drivers being taught to drive efficiently in a few days or even hours; the overall length is short; they have a high figure of reliability due to simple construction and the absence of rotating parts, and consequently low repair costs; they are clean, sanitary and free from fire risks. The most common, in fact practically the only criticism levelled at the electric vehicle is its low speed, but what is required for town work, where this type has its field, is the maintenance of a reasonably high average speed. This is obtained by electric vehicles because of their easy control and high acceleration, and numerous observations go to show that when compared with petrol vehicles on the question of speed, the latter with probably 75 per cent. greater maximum speed, has no time saved to its credit at the end of the day. The *Central Station* of America published some time ago the following results of a series of tests between a petrol and an electric lorry geared respectively for a maximum speed of 12 m.p.h. and 18 m.p.h. The course was triangular and the roads good. Duration of stops in the case of (*a*) 2 minutes, (*b*) 1 minute, number of stops 24, distance between stops 0·42 mile.

		Average Speeds.	
		Electric.	Petrol.
(*a*) Leg 1 level		10·76	9·41
2 up		7·08	8·85
3 down		11·12	7·2
Average		9·65	8·48
(*b*) Leg 1 level		11·4	10·08
2 up		6·9	7·83
3 down		11·8	10·56
Average		10·03	9·48
General average ...		9·84	8·98

This shows the average speed of the electric lorry to be approximately 10 per cent. higher, although geared and powered for a 30 per cent. lower speed.

The reliability of the electric vehicle is becoming proverbial, and if need be it would be quite feasible to run an electric vehicle for 365 days in the year. Brock. man, in a paper given at Glasgow, gave the relative ratios of working days to days in commission as electric 95 per cent., petrol 90 per cent., steam 85 per cent., whilst the author would be inclined to place the electric at 2 per cent. better than this. Little difficulty is experienced in obtaining adequate supplies of electricity, and the position in regard to this is improving daily.

Electric power is exceedingly flexible in its application, and will readily admit of vehicles being designed for special purposes in a way which will allow of the maximum possible duty being obtained from them.

The "Fram," which was a French machine, is an instance of the possibilities of designing electric chassis for special purposes, and these machines were used in large numbers for refuse collection by the Municipality of Paris. The power unit is complete in the form of a detachable forecarriage with battery and motors coupled direct to each wheel. A feature of the Fram control is that steering is assisted by accelerating the outside motor above the speed of the other by means of an automatic attachment to the steering wheel. This throws 27 cells out of the complete 44 on to the motor, which requires to run the faster, as against 17 on the other. The front wheels revolve on a fixed axle, and in steering, the whole forecarriage turns as in a horse vehicle, an extremely large lock being obtained. Regenerative braking is used, and in descending stiff gradients currents up to 80 amperes returned to the battery.

Wheel drives, where the motors are built into the wheels, have been used to a considerable extent, and these allow of two or all four wheels being driven and also a certain amount of additional latitude in the design of special-purpose chassis. In this class beside the "Fram" and the Mosnay, we may note the Cedes, in which a slow-speed gearless motor is built into the wheel, the C.T. internal gear drive, the motor and pinion being concentric with the gear ring and engaging through a cluster of idler intermediate wheels, and the couple gear, in which a high-speed motor is carried in a horizontal position within the wheel itself and having a bevel pinion on each end of the shaft gearing with two bevel rings on which the road wheels are mounted. The motor is set at a slight angle to the plane of the wheel, so that the pinions engage with their respective halves of the racks whilst being free of the other half. A reduction of 25 to 1 is used and an efficiency of 97½ per cent. is vouched for by the American Bureau of Standards.

With regard to the driving gear in general, final chain drives are efficient when new, but tend soon to become noisy owing to the multiplicity of small joints which are exposed to dust, dirt and the action of the elements, and which it is very difficult to keep lubricated. Bevel gear drives, double-reduction and worm gears as usually designed all mean a heavier rear axle than the chain drive, and owing again to this increase in weight the gears themselves require to be made heavier to stand the severer shocks entailed and to which they are subjected. Bevel gears necessitate exceedingly fine adjustment and therefore skilled attention, and for these reasons are not desirable components of a road vehicle. Its use on the heavier vehicles has already been much reduced whilst it is being slowly eliminated from the lighter ones. Worm gear has been much improved during recent years, but its overall efficiency under varying road and load condition is a very questionable quantity, and its use, especially with electrically-driven vehicles, is not at all desirable. Wherever possible spur gear and preferably internal gear should be made use of for the heavier classes of vehicle.

Petrol-Electric Vehicles.—To enable vehicles to cope with distances which are beyond the capacity of battery vehicles and yet to retain the advantages of electric transmission, several petrol-electric systems have been successfully developed and used with advantage for omnibus service, especially where heavy routes have to be covered. In the Tilling-Stevens system, illustrated diagrammatically by Fig. 50, the gear-box of a petrol motor is replaced by an electric generator coupled to the engine which supplies current to a motor driving a live

Fig. 36. ELECTRICALLY OPERATED TIPPING BODY

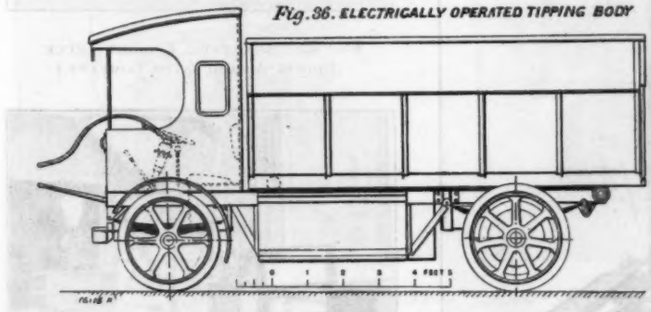


FIG. 37. "YORKSHIRE" 6-TON STEAM LORRY, WITH 2-TON POWER OPERATED CRANE.

FIG. 38. ELECTRIC LORRY (G. V. CO.) WITH WILKIN'S UNLOADING GEAR.

axle of usual type. Dartnall in his Paragon transmission employs a petrol-driven alternating-current generator with what he terms a clutch motor, the case of which revolves fixedly with the engine and generator. Control is obtained by altering the connections of the clutch motor field so as to drive its rotor at 50 per cent. below, or at engine speed or 50 per cent. above engine speed, as desired, the rotor being coupled direct to a standard-type rear axle. On the second speed a magnetic clutch drives the rotor mechanically, and the clutch motor electrical losses are then cut out.

The Thomas transmissions is a further variation of the

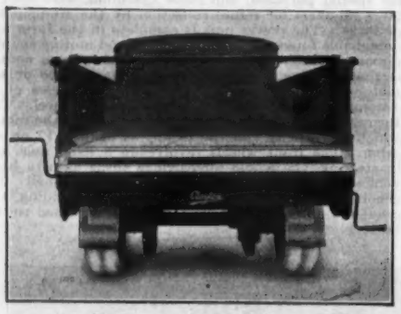


Fig. 39. 5 Ton Steam Wagon (Clayton) with Wilkin's Gear.

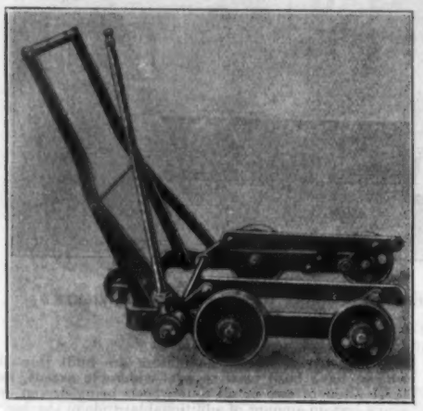


Fig. 41. U Frame Jacktruck (Hardaker).

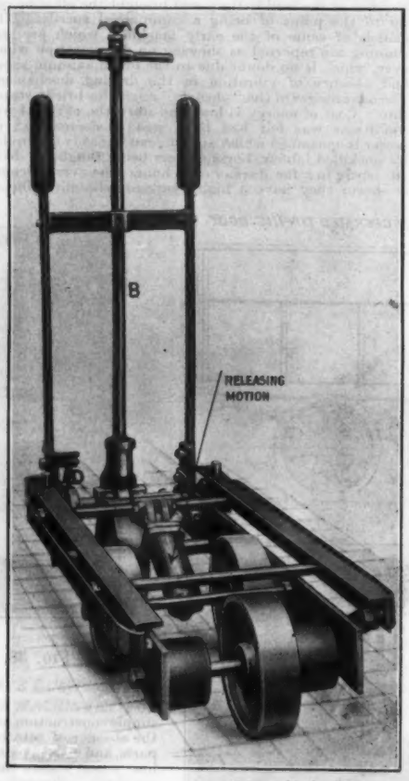


Fig. 40. 15-Cwt. Jacktruck (Hardaker).

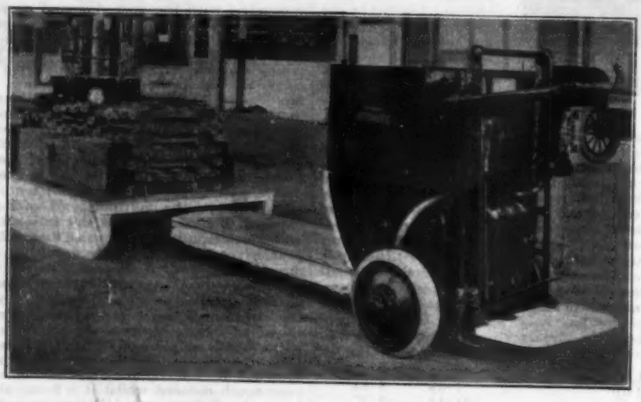


Fig. 43 Gear-Drive Truck, with Electric Lifting Device.

petrol-electric drive where the lower speeds are dealt with electrically, but on full speed the electric motor is cut out and its losses eliminated by a direct mechanical drive. Hydraulic transmission with oil as the working fluid has been tried to a limited extent, and the variable-stroke pump driven by the engine gives an easy speed control with an infinite number of steps.

Figs. 51 and 52, page 767, illustrate an unique system of electric traction in use in Bradford which, although apparently having only a limited scope at present, may contain germs capable of great future development. A chassis is equipped with two 500-volt 20-h.p. motors with series parallel control and switch gear to allow of its running on rail-less routes with positive and negative wires, on tramway routes with earthing shoe on rail, or off the main routes by means of the battery. The connections are so arranged that the battery can be placed in series with the motors for charging whilst running on the trolley routes.

The battery consists of 124 Edison B4 cells, which have a capacity sufficient to run the vehicle for 10 miles on average roads. The vehicle was put into service in May, 1916, and has operated since then chiefly on the collection and delivery of tramway stores, although for the past six months it has also been used on a parcel service between Bradford and Leeds. Fig. 52 shows the vehicle on a rail-less route with positive and negative wires, whilst Fig. 51 shows it on an ordinary road in condition for running on the battery. Running on a tramway route involves the necessity of earthing to the rail, and Cross's steering arm and earthing shoe shown in Fig. 53 were designed for this purpose. It is obvious that the present arrangement of 500-volt motors and a battery giving 130 volts is not ideal, and can only be a success when running for the major portion of its time on the trolley routes, the battery being used only for short deviations and shunting when collecting or delivering goods.

Mention is made in the report previously referred to, that it would be advisable to provide facilities for carrying out tests on the roads, and the author would draw attention to the ease and accuracy with which tests can be made on electrical apparatus. Even figures taken in the course of ordinary daily running, which can only be approximately correct, give very useful information, and information with an accuracy which cannot hope to be approached with steam or petrol vehicles. Fig. 53, page 768, for instance, shows the consumption of electricity throughout twelve months for three vehicles of different capacities and working on different routes. It will be noticed that they all exhibit the same general contour, and bring out the fact that for that particular period there were three peaks of bad weather and road surfaces, whilst in the case of L.M. 9940 the high peak in January was found to be the result of running the

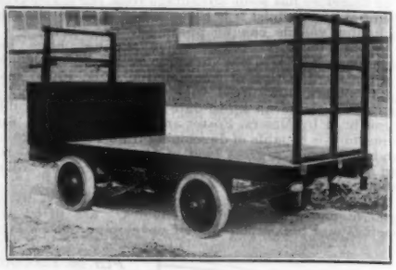
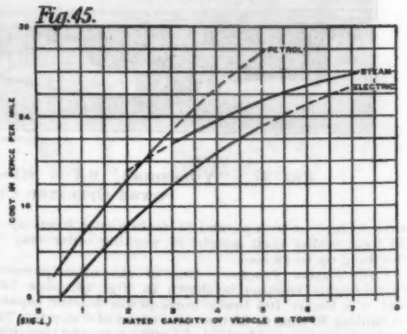


Fig. 42. Automatic Freight Truck. (Edison Accumulator Company.)

Fig. 44. Automatic Truck with Crane attached.



vehicle with a broken spring. Defects such as this are quickly detected if such records are properly inspected and the information obtained made use of intelligently. Another instance, showing the ease with which defects are noticed on electric vehicles, occurred when two identical vehicles were run out on trial, supposedly after being properly tuned up, when it was found that one gradually drew away from the other and showed a speed of 1¼ m.p.h. faster. Investigation showed that the front wheels were out of alignment, and after these were adjusted the two vehicles made the return journey together, only a few yards separating them the whole way.

The following is also a case in point, and, as the results are somewhat interesting, the author takes the liberty of quoting them here. A short time ago cars without differential were built in America, whilst similar construction is contemplated in this country, and as the desirability of eliminating the differential was obvious as allowing of simpler and cheaper design, the author was prompted to run a series of tests with a view to putting a value on this item of the vehicle mechanism. A 15-cwt. van built by the Electromobile, Limited, was available, and the series of tests given in the* table below were run over the same course, by the same driver, and under the same weather conditions. The vehicle was designed for a speed of 15 m.p.h. and weighed,

* *Electrician*, August 31, 1917.

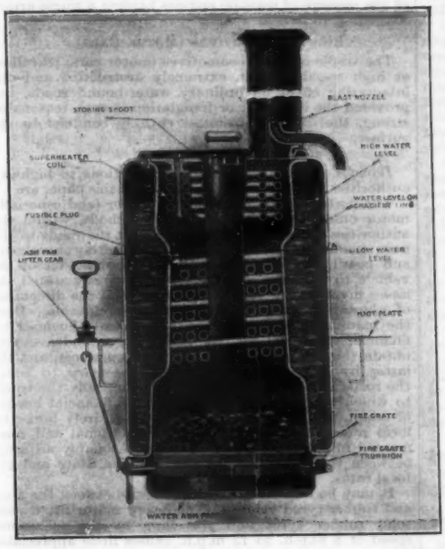
complete with battery, 30 cwt. The electrical equipment consisted of a 60-cell A4 Edison battery supplying current to a double commutator motor and with a modified series parallel system of control. The chassis was arranged with an all-gear drive, the motor driving the live axle through double-reduction double helical gear, whilst a bevel differential of normal type was fitted. The differential was securely locked when required, by the insertion of brass blocks between the pinions and meshing with the same, no movement being then possible.

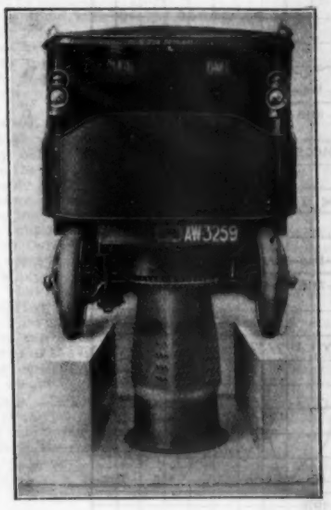
different appearance from that of a tyre running under ordinary conditions.

The question of passenger transport has not been specifically treated, but from what has already been said it will be clear that the bulk of the general work will be carried out by petrol vehicles, although the steam, electric battery, and petrol electric-driven 'buses, and where the traffic route is well defined the electric trolley 'bus and tram-car have their fields. The latter, however, appears to have had its day of usefulness, and in all

vision of sorting space at one or both ends of the main journey.

(c) The most economical method of dealing with bulk loads for short distances, except possibly in cases where railway sidings and loading machinery is already installed would appear to be by road vehicles with bodies designed to suit the particular traffic to be dealt with, and by the adoption as far as possible of loading and unloading labour-saving devices. The use of road vehicles has the advantage of reducing the handling of the goods to a minimum.





FIGS. 46 AND 47. WATER-TUBE BOILER (SENTINEL). SECTION AND OPEN FOR INSPECTION.

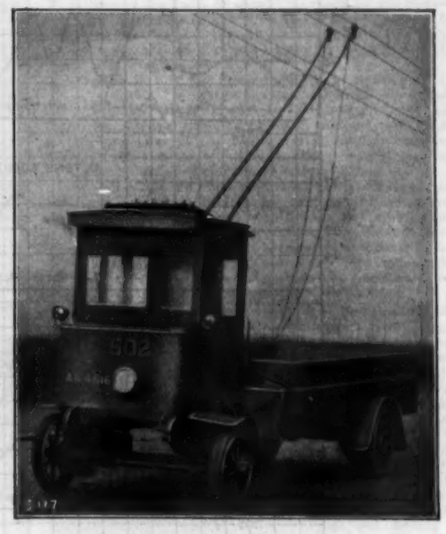
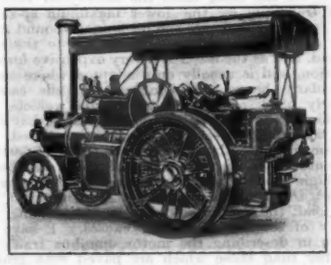


FIG. 51.



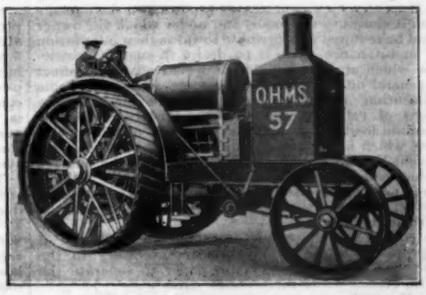
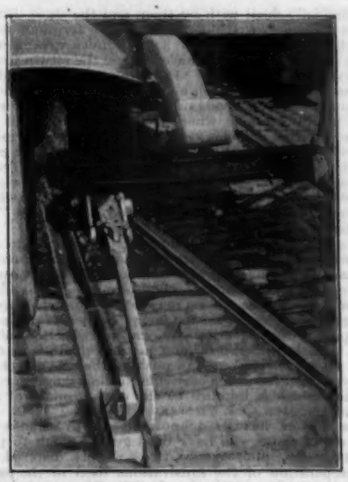
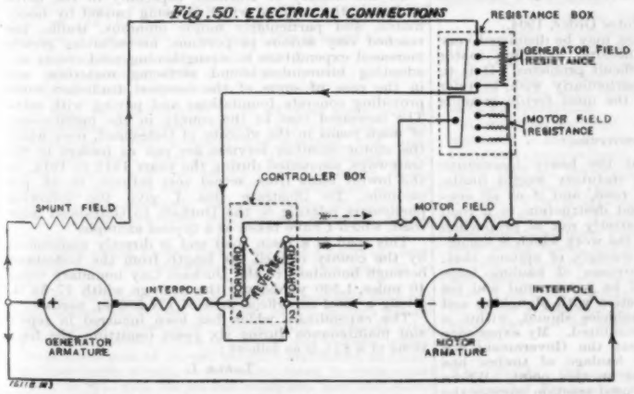


FIG. 48. 14 20 H.P. STEAM TRACTOR (FOSTER). FIG. 49. 105 H.P. PETROL TRACTOR (FOSTER).



FIGS. 51 AND 52. BRADFORD VEHICLE, RUNNING ON BATTERY, TRACKLESS TROLLEY ROUTE, AND EARTHING SHOE (CROSS).



The current consumed was measured by a Sangamo ampere-hour meter, and showed current as charged to the battery, not battery output, as is more generally the case. The Table of results on this page show that, both light and loaded, the consumption of current is greater when the differential is out of action, the percentage difference increasing with increase of load. This is to be expected, as with increased load the tyres will grip the road better and more power be required to cause one wheel to slip when travelling on a curve. As the machine runs entirely on ball bearings, the whole of the additional power is apparently absorbed by extra wear on the tyres, the face of the tyres, even after only a small mileage had been run, presenting a totally

likelihood will largely be replaced by rail-less vehicles, the obstruction caused by the track and its cost of maintenance being the *bête noire* of the rail-bound system. Electric runabouts and small closed cars will no doubt come largely into use for town work and be used by ladies for shopping purposes and by professional and business men making calls, their ease of control, cleanliness, quietness and economical operation, being greatly in their favour.

In conclusion, the goods transport problem might be summarised as follows:—

(a) The collection and delivery of miscellaneous traffic from traders having an intermittent daily average of only a few hundredweights.

(b) The collection and delivery of miscellaneous traffic from traders having sufficient traffic to warrant the use of containers or demountable bodies.

(c) The transport of bulk loads for short distances.

(d) The transport of bulk loads for long distances.

(a) calls for the use of economical vehicles with high acceleration and easy control such as is obtained in the electric vehicle, the high-powered petrol vehicle on such a service being wasteful of fuel and highly expensive in repairs, and the provision of sorting facilities at one or both ends of the main journey.

(b) necessitates the provision of apparatus for loading and unloading the complete bodies with an average weight of probably 3 tons, together with the provision of sorting space at one or both ends of the main journey.

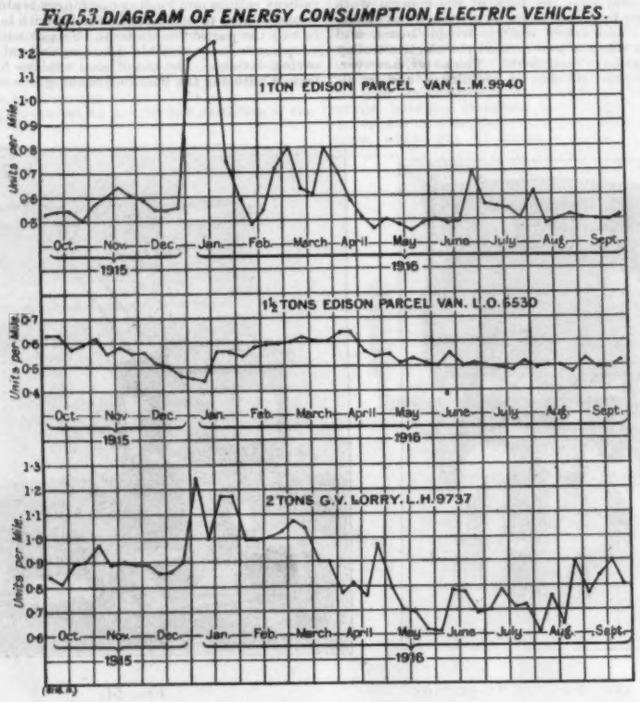
(d) Goods in bulk to be transmitted long distances appears to call for containers of some form suitable for transfer to and carriage by rail. This means haulage by road vehicle and the lifting of the body into the rail wagon by overhead crane. Where machinery exists for even the loading only of material such as, say, limestone, coal and iron, it would not appear to be economical to provide separate containers, the additional tare weight

Condition of Differential.	Load.	Miles.	Amp.-Hours.	Amp.-Hours per Mile.	Saving per Cent.
Locked ..	Light	18·1	100	5·52	—
Free	Light	18·1	99	5·13	7
Locked ..	11 cwt.	18·1	125	6·90	—
Free	11 cwt.	18·1	110	6·08	12

and possible reduction of net paying load more than compensating for any saving which might accrue from their use. The miscellaneous traffic may be long or short distance, and all of it required to be sorted. The railway companies and a few of the haulage and express delivery contractors have the necessary sorting space, and, therefore, all miscellaneous traffic should be more

MECHANICAL ROAD TRACTION.

Fig. 53. DIAGRAM OF ENERGY CONSUMPTION, ELECTRIC VEHICLES.



economically dealt with by them and the short-distance goods then conveyed by road from the terminal station to points within a radius of, say, 10 miles, arrangements being made so that the vehicles call on the return journey for miscellaneous goods. Handling would be reduced and much time saved on short-distance goods, and the uneconomical local goods stations done away with or only used for bulk traffic where such exists. For all such traffic the road vehicles should be provided with removable bodies into which the traffic can be sorted ready for the vehicle on its return to the station. Traders delivering their own goods would preferably use electric vehicles within a radius of 10 miles and petrol vehicles beyond this, with, when required, "steamers" for heavier work.

It is to be hoped that sufficient has been said to show the present state of the art of road transport from the mechanical engineering side and to point out means of improvement in economy, which are already available. In doing so, further means may now suggest themselves and greater progress be made in the near future. In transport work, as elsewhere, careful selection of the right tools is imperative, and a great mistake is often made by commercial men in pushing the sale of vehicles of a type unsuited to the particular business under review, a policy which is inimical to the advancement of road locomotion.

The author has to acknowledge with thanks the kindness of those who have been good enough to place the diagrams, photographs, &c., at his disposal, for the preparation of the illustrations used in the paper, especially Sir Henry Fowler, K.B.E., Messrs. the B. F. Goodrich Company, *The Electrician*, and *The Railway Gazette*.

HEAVY MOTOR TRANSPORT AND ROAD CONSTRUCTION.

We reprint below abstracts of three papers which were discussed together on November 25, at the Road and Transport Congress of the County Councils Association, held at the Royal Agricultural Hall, Islington.

The Weight, Construction and Speed of Mechanically-Propelled Vehicles in Relation to the Construction and Maintenance of Roads.

By Albert E. Brookes, County Surveyor and Engineer, Durham County Council.

It is beyond question that the self-propelled vehicle, especially that of the light and heavy motor type, has become a necessity to modern economic life. It provides a cheap, rapid and reliable means of transport for passengers between the towns and their suburbs, for goods and merchandise between the ports and the centres of manufacture and points of distribution, and very materially tends to relieve congestion on the railways. This latter fact has been very deeply impressed on even the lay minds by the great success achieved by the Ministry of Transport in utilising motor transport in maintaining the food supplies of the country during the serious crisis caused by the recent railway strike. Although there is a strong concensus of opinion that some improvement in the rules and regulations affecting this class of vehicle is necessary to minimise the damage which it causes to the roads, and under which the owner should be required to contribute towards their adaptation and maintenance, there is no desire to suggest restrictions which are unreasonable or would adversely affect the general interests of the transport industry. Some modification could with advantage be made in the designs of vehicles, especially in connection with the maximum loaded axle weights, diameter of wheels and speed, which would not seriously affect the efficiency of the vehicles and would considerably reduce the damage to the roads. It is to the advantage of the vehicle owners or users to use every endeavour, even at some sacrifice, to attain this end, as the better the roads the less their running costs.

In considering the weight, construction and speed of self-propelled traffic it only appears necessary to the author for the purposes of this paper to separate the several classes under three heads, namely :—

(*a*) Heavy Locomotives (Traction Engines), Highways and Locomotives Acts, 1878 and 1898.

(*b*) Light Locomotives (Motor Cars), Motor Car Acts, 1896 and 1903.

(*c*) Heavy Motors, Heavy Motor Order, 1904.

The first two in the above list may be dismissed very briefly; the latter, heavy motors, including motor omnibuses, offers the most difficult problems. It is to this class of traffic that I particularly wish to refer and which I think opens up the most fertile grounds for useful discussion.

Heavy Locomotives.

I express the opinion that the heavy locomotive train, loaded to the existing statutory weight limits, is unsuitable for use on any road, and if at all concentrated will cause injury and destruction to a road in any class of construction utterly out of proportion to the value and advantage of the work which is accomplished by its means. I am strongly of opinion that, excepting for the special purposes of hauling large indivisible loads which cannot be put on rail and for agricultural purposes in connection with ploughing and threshing, the use of these vehicles should, within a reasonable time, be entirely prohibited. My experience in dealing with claims against the Government for damage caused to roads by haulage of timber has provided indisputable evidence on this point. Where contractors have continuously used traction engines the roads have been so utterly destroyed that it has been necessary to entirely reconstruct, whereas the use of heavy motors, especially the rubber-tyred variety, has, except in cases of very weak roads, to a great extent limited the damage to the surface. In the early days of the war very large fleets of traction engines were employed by contractors in connection with the construction of the large hutted camps with most disastrous results to the roads affected, and although large sums of money were expended in an endeavour to maintain this traffic the result was not a success until, on the advice of the Road Board, the use of heavy locomotives was entirely abandoned and rubber-tyred heavy motors substituted.

The report of the Departmental Committee does not recommend any very drastic alterations to the law affecting heavy locomotives, but the following are of some importance :—

1. A clearer definition of weight.
2. Amendment respecting diagonal cross-bars on driving wheels.
3. Regulations restricting the weight to be carried by wagons drawn by locomotives similar to those applicable to vehicles drawn by heavy motors.
4. Advance notice of 72 hours to county surveyor of the passage of traction engines hauling a single article exceeding 16 tons in weight.

Light Locomotives (Motor Cars).

The traffic of light locomotives (motor cars) travelling at high speeds has an extremely destructive and disintegrating effect on ordinary water-bound roads, but provided the sub-crust or foundation is even reasonably strong, the damage is almost entirely confined to the surface.

Heavy Motors.

Damage.—The most important questions to highway authorities which arise under the title of this paper are :—

The destructive effect of heavy motor (and especially motor omnibus) traffic; the best methods, within the authorities financial limits, of adapting the roads to the new conditions; the large capital outlay involved; and possible improvements in the construction of the vehicle to minimise damage. As previously stated the issues involved are very complicated, and the difficulties of adaptation are great, but not insurmountable. Both the manufacturer and the authority are influenced by financial considerations, the former in an endeavour to obtain the maximum result at a minimum cost, and the latter by the capital expenditure necessary to adapt the roads to a standard to carry economically the traffic to which they may be exposed. This financial burden of adaptation is far too serious to be entirely borne by local rates; it is a matter of both national and commercial importance, and should be reasonably adjusted between the owners of the vehicles, the State and the local rates.

It may be advisable to differentiate between the steel and rubber-tyred vehicle. The heavy motor fitted with solid rubber tyres and travelling at the maximum speed of 8 m.p.h. to 12 m.p.h. causes little appreciable damage to a road paved with granite setts on a concrete foundation, but on an ordinary water-bound or even a bituminous-bound road without good foundations the effect is disastrous, resulting in corrugation of the surface and distortion of the crust, which becomes accentuated in an increasing ratio as the deterioration proceeds. On the other hand the steel-tyred vehicle, although travelling at the lower maximum speed of 5 m.p.h., not only damages the bituminous-bound road, but also causes very serious deterioration to the sett-paved road, and as the latter is a very expensive form of construction, and is usually only adopted where traffic is particularly heavy and concentrated, the case is particularly black against the steel-tyred vehicle. In the opinion of the author it is very desirable that steel tyres on heavy motors should be entirely abolished.

The damage caused by heavy motor traffic is particularly accentuated in the case of that of motor omnibuses, due to high speed (usually considerably in excess of 12 m.p.h.), the small diameter of wheels employed, the varying load, the continual stopping and starting, the regularity of service, and other causes. I have no hesitation in describing the motor omnibus traffic on roads other than those which are paved with granite setts as the most destructive traffic with which the road engineer has to contend.

In the County of Durham, especially in the north and east, the damage which is being caused by heavy motor, and particularly motor omnibus, traffic, has reached very serious proportions, necessitating greatly increased expenditure in strengthening road crusts and adopting bituminous-bound surfacing materials, and in the case of some of the heaviest trafficked roads providing concrete foundations and paving with setts. The increased cost to the county in the maintenance of main roads in the vicinity of Gateshead, over which the motor omnibus services are run as feeders to the tramways, amounted during the years 1912 to 1915, on the lowest basis from actual cost returns, to 4*d.* per car-mile. To illustrate this I give the following particulars relating to the Durham to Gateshead main road, which I have taken as a typical example.

This road is a main road and is directly maintained by the county council, its length from the Gateshead borough boundary to the Durham City boundary being 10 miles, 1,540 yards, and the average width 27·35 ft. giving a total superficial area of 174,356 sq. yards.

The expenditure which has been incurred in repair and maintenance during six years (omitting the fractions of a £1), is as follows :—

Table I.

——	Total Cost.	Cost per Mile.	Cost per Yard Superficial.
Before Motor 'Buses Commenced.	£	£	*d.*
1909–10	2,710	249	3·73
1910–11	2,996	275	4·12
1911–12	2,916	268	4·02
After Motor 'Buses Commenced.			
1912–13	3,377	310	4·65
1913–14	9,910	911	13·64
1914–15	8,667	797	11·92

Taking, in round figures, the years 1913–14 and 1914–15, at 850*l.* per mile per annum, as against 310*l.* per mile in 1912–13, the year in which the 'buses commenced running, there is an increase in cost of 175 per cent., the greater part of which is attributable to motor-'bus traffic.

The following table is an average summary of a census of traffic taken at two points, contrasting motor-'bus traffic and heavy motor traffic with the total of all other traffic, both in weight per yard width of road, and as a percentage of the whole, for the years 1912 and 1914 :—

TABLE II.

(1)	(2)		(3)	
	1912.		1914.	
Description of Traffic.	Tons per Yard Width of Road per Day.	Per-centage of Total Weight.	Tons per Yard Width of Road per Day.	Per-centage of Total Weight.
Motor 'buses ..	0·5	0·6	43·8	30·4
Heavy motors and tractors	16·9	21·6	34·3	24·7
All other traffic	60·3	77·8	63·3	44·9
	77·7	100·0	141·4	100·0

Taking the summary of figures in Table II, the following results are obtained :—

Between the census of 1912 and that of 1914 :

Motor omnibus traffic has increased from 0·6 per cent. to 30·4 per cent. of the whole.

Heavy motors and traction-engine traffic has increased from 21·6 per cent. to 24·7 per cent. of the whole.

All other traffic, including motor cars, has decreased from 77·8 per cent. to 44·9 per cent. of the whole.

I have shown in Table III the actual expenditure incurred in 1911–12 and 1913–14 as set out in Table I,

TABLE III.

Description of Traffic.	1911–12.			1913–14.			Increase in Cost 1913–14.		
	Total.	Per Mile.	Per Square Yard.	Total.	Per Mile.	Per Square Yard.	Total.	Per Mile.	Per Square Yard.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	£	£	*d.*	£	£	*d.*	£	£	*d.*
Motor 'buses	17·5	1·6	0·02	3,013	277	4·1	2,995·5	275·4	4·08
Heavy motors and tractors ..	629·9	57·9	0·9	2,448	225	3·4	1,818·1	167·1	2·5
All other traffic ..	2,268·6	208·5	3·1	4,449	409	6·1	2,180·4	200·5	3·0
	2,916·0	268·0	4·02	9,910	911	13·6	6,994·0	643·0	9·58

dissected between three classes of traffic in proportion to their percentage of the whole, as set out in Table II, and have shown the increase in cost thus attributed to each.

To reduce the results arrived at to a car mileage basis I have taken the services of omnibuses from the published time-tables, and have calculated the car-mileage made on the average daily car journeys and the length of main road traversed, which works out at 504·56 car-miles per day, or 184,163 car-miles per annum. Based on the increase of cost shown in Table III this is equal to—

A total increase in cost of 2,995·5*l.*,
An increase per mile of 275·4*l.*,
Or an increase per car-mile of 4·08*d.*

It may be questionable as to whether some part of the increased expenditure during 1913–14 is not capital expenditure. Pitch grouting was adopted, and some additional crust strength no doubt accrued. The general result was not satisfactory, the traffic badly punishing the new sections. The expenditure on this road has not materially decreased since, although the 'bus services have been considerably curtailed during the war.

I regret owing to war conditions that I have not been able to bring my statistics respecting this road up to date.

In the author's opinion it is only reasonable that not only motor omnibuses, but also heavy motors should make some reasonable contribution towards this additional expense, which is entirely due to their traffic. The pre-war rate of 4*d.* per car-mile attributed to motor omnibus traffic would, at prevailing rates, be quite equal to 6*d.* or 8*d.*, and the author considers that the motor omnibus should not only contribute on a car-mileage basis but should also bear some proportion of the cost of adapting the road, and especially so on a road on which the capital outlay would not be otherwise required. These companies, except under special conditions laid down by Parliament in private Bills, for which conditions the highway authorities may have had to put up a strenuous fight, make no contribution towards the maintenance of the highway, other than through the petrol tax or the Hackney carriage licence fees, and may not even be rated (for depots, &c.) within the county or district in which the omnibuses are run. In this respect they are in a very advantageous position compared with that of a tramway company, who not only have to bear the capital cost of constructing their tramway but have also to maintain the whole width of the road occupied by their track, and they also pay towards local rates on the assessable value of the track and overhead equipment. The author suggests that motor omnibuses should contribute from 25 per cent. to 33 per cent. of the cost of adaptation where it is necessary, and in addition at the rate of at least 2*d.* per car-mile towards maintenance, and that heavy motors should be licensed subject to a fee which would be equivalent to, say, 1*d.* per car-mile, which, on an average yearly mileage of 10,000 miles would be equal to an annual charge of 41*l.* 13*s.* 4*d.*

In last year's session of Parliament powers were sought by certain local authorities to run motor omnibuses outside their area in the County of Durham. The county council, in opposing succeeded in obtaining clauses by which the promoters were required to contribute towards the cost of adapting the roads over which they sought powers to run and to contribute towards maintenance at the rate of 1½*d.* per car-mile.

Restrictions and Regulations.—As a basis of discussion the author submits the following proposals relative to heavy motors, which he suggests would not seriously affect the commercial value of the vehicles, would considerably contribute to reducing damage and would therefore ultimately be to the advantage of the user of the road and the community generally.

1. That the minimum diameter of 4 ft. recommended by the Departmental Committee for wheels fitted with steel tyres for an axle exceeding 6 tons in weight should also apply to wheels fitted with rubber tyres.

2. That steel tyres on heavy motors should be entirely prohibited.

3. That the car should be designed so that when loaded the centre line of the load should be sufficiently in front of the back axle as to ensure the maximum load being carried without exceeding the maximum single axle weight.

NOTE.—In several designs of motor wagons the centre line of the load is behind the back axle and from 70 per cent. to 75 per cent. of the total weight of the loaded car is on the rear axle.

4. That if fitted with pneumatic tyres the speed of heavy motors, not exceeding 6 tons in weight, might be increased to 20 m.p.h., and those exceeding 6 tons to 12 m.p.h.

5. That heavy motors, other than motor omnibuses, should be annually licensed subject to the payment of fees based on weight and power or on a mileage basis.

6. That motor omnibuses should be similarly licensed and subject to a fee of 2*d.* per car-mile, and should contribute towards the cost of adaptation where adaptation is necessary.

7. That as regards motor omnibuses the provisions of the Local Government (Emergency Provisions) Act, 1916, be made permanent.

8. That motor char-a-bancs trading from centres, although not picking up passengers *en route*, should be subject to the same regulations in respect to licence fees as motor omnibuses.

A question seriously exercising the minds of road engineers, is that in constructing and surfacing roads to withstand economically the action of heavy motor traffic they are rendering the roads exceedingly difficult and dangerous for horse traffic which has an equal right of user. This is especially so in hilly and undulating counties such as Durham. The author is continually receiving complaints from horse owners of the slippery state of the roads, and has had to arrange for extensive gritting, especially during the winter months. To meet the difficulty it would appear that at no very distant date a separate carriageway will have to be provided for motor vehicles on all main arterial roads, which may again have to be subdivided between fast and slow traffic.

The Weight, Construction and Speed of Mechanically-Propelled Vehicles in Relation to the Construction and Maintenance of Roads.

By GEORGE HOARE.

THE outstanding value and importance of the work done by steam vehicles during the great war cannot be too strongly emphasised. One wonders, indeed, how the enormous quantities of building materials, munitions, timber, &c., could have been transported had it not been for these extremely robust and dependable machines, using native fuel, a point the importance of which (particularly in view of our experience of submarine warfare) should not be overlooked. Moreover, the recent railway strike emphasised in no uncertain sense the extreme importance alike of reliable machines and suitable roads, and proved that our existence in a very real sense depend upon the efficiency of our roads and machines. It will, moreover, be admitted that the transport services of this country cannot be considered complete without steam tractors and steam wagons.

The manufacturers of steam tractors and steam wagons aim at producing machines as reliable as railway engines, although the conditions under which they work are not ideal and constantly vary, not only on the level but also up hill and down.

The steam tractors and steam wagons now in use give general satisfaction, although it may be stated quite frankly that, notwithstanding an honest effort to meet the situation the limit of weight imposed by the Statute has up to the present restricted the designer, and he has had considerable difficulty in meeting the actual needs of the user, and at the same time complying with the legal weight laid down.

Hitherto it has not been possible to include in the legal "unladen" weight of the machine all the equipment found to be either necessary or desirable. It has, however, always been recognised that certain things could form part of the load, and advantage has been taken of this, otherwise the machines could not have been so successful as they have proved to be.

The manufacturer, however, does not see the practical value of "unladen" weight for such machines, as from the point of view of the construction and maintenance of roads, the total moving weight of the loaded unit is the all-important matter. At present that limit is 20 tons made up as follows :—12 tons for the engine part (4 tons on front axle and 8 tons on the back axle) and 8 tons on the trailer (i.e., 4 tons per axle).

If, however, "unladen" weight is to be retained, then it would be an advantage if the manufacturers of engine and the road authorities could agree as to a definition of "unladen" weight. The recommendation of the Local Government Board Departmental Committee on this subject, viz., "We recommend that 'unladen' weight should be defined for all purposes to include all parts of the car which are necessary, to, or ordinarily used with, the car when working on the roads, but should not include the weight of water, fuel or accumulators (other than boilers) used for the purpose of propulsion, or of loose tools or loose equipment," would in all probability have been quite differently worded had the case of steam tractors been definitely before them. Their recommendation in its present form can hardly be regarded as satisfactory either to the manufacturer or to the road authorities.

As a basis for consideration, and with a view to general agreement, the following definition, which represents more or less the practice of the last fifteen years, is put forward, viz., "That the 'unladen' weight of 6 tons recommended by the Local Government Board Committee should be interpreted as 'excluding everything not essential to steaming on or off the weighbridge'."

Such a definition would cover existing engines and meet all practical requirements and ensure the classification or type of engine which for seventeen years has been manufactured and used under the Light Locomotives Act.

Some manufacturers would prefer the "unladen" weight fixed at 6¼ tons, in view of the fact that tractors can never be as heavy as the steam wagon loaded weight, and it is difficult to see any valid reason against fixing the "unladen" weight at 6¼ tons as desired.

The "unladen" weight, whatever it may be, will always be under the actual weight of the complete working engine, and therefore manufacturers feel that except for the purpose of determining the type or classification of the engine, "unladen" weight can be of no practical value.

Further, it has been found that unless the weight of the engine is sufficient to secure a firm grip of the road surface, there is a tendency for the driving wheels to skid or slip. This is not always because the weight hauled is excessive, as it may and often does happen when the load hauled is less than the legal limit. It may happen on hills or bridges even with light loads. The Local Government Board Departmental Committee recommend an increase of 1 ton in the unladen weight, obviously with a view to permitting additional weight in order to prevent skidding.

Skidding (or slipping,) whenever it takes place, and from whatever cause, is calculated to do considerably more damage to the road surface than additional weight, besides the liability to accident through loss of grip.

Manufacturers feel that wider spaces between the strakes would in most cases prevent slipping, and consequently damage the road surface less than wheels shod in accordance with the present regulations, and therefore suggest that for wheels not under 4 ft. 6 in. in diameter the space allowed should be one-fourth of the width, instead of the present one-eighth. Surveyors (amongst others) sometimes ask for wider spaces for their own engines. Moreover, the War Office have special legislation permitting wider spaces and an extra ton in weight, and if such be made of general application it would go a long way to meet the need.

In asking for wider spaces between the strikes on the wheels of steam tractors, it must not be assumed that it is proposed to put heavier pressure on the road surface than has been hitherto recognised as a reasonable weight, as under present regulations a 9½ cwt. unit of weight per inch in width is allowed in driving wheels 5 ft. in diameter, as set out on page 15 of "Width of Tyres Exemplification, 1904." The total back axle weight of the steam tractor when fully laden would not exceed the 5 ton 4 cwt. 2 qr. named in Table XIII, page 15 of the above. Therefore, a total width of 5¼ in. on each driving wheel would be sufficient to comply with the 9½ cwt. unit of weight per inch. If, therefore, the bearing surface of the strakes always in contact with

the road surface is never less than 5½ in. at any point, then the present requirements are fully met.

Experience has shown that these engines can be profitably employed at considerable distances from their base, sometimes in districts where coal and water cannot be readily obtained, and therefore it becomes necessary to provide additional water and fuel-carrying capacity. For many classes of work, such as, for instance, hauling road metal and timber supplies, engines have frequently to remain in station yards and such-like places without proper protection, and therefore a demand for longer awnings has arisen, thus again adding to the weight.

There are times when three speeds can be profitably employed, as giving a larger range of speed ratios, and this is oftentimes a distinct gain from the road point of view, inasmuch as the slower speeds provided enable tractors to ascend hills of varying gradients, whereas otherwise slipping might take place and thereby damage the road surface.

In looking to future developments, rubber tyres or rubber pads should be provided for, but this again will add to the weight.

Then, again, certain classes of work require special attachments, such as additional hauling drums and ropes, interchangeable road roller parts and jib cranes with equipment and loose tools when supplied, should be allowed extra to the legal "unladen" weight, provided they did not make the engine heavier than the legal laden weight.

Trailers.—Manufacturers also feel that there are times when a somewhat higher axle weight should be permitted to trailers, when used with steam tractors. Surveyors are themselves largely interested in steam haulage, and frequently ask for tipping trailers—both end and side-tipping. These designs call for extra weight, and it would assist manufacturers to meet the demands of their customers and at the same time check illegal overloading if the trailer axle weights were raised from 4 tons to 5 tons, thus permitting a gross trailer weight of 10 tons, as against the present limit of 8 tons.

Even then, the total loaded moving weight of a steam tractor and trailer would be considerably less than the present legal moving weight of steam wagon and trailer.

"Unladen" weight in regard to trailers is regarded as entirely unnecessary. It is the loaded weight only that matters, and therefore "unladen" weight in regard to trailers should be entirely abolished. This view was, in fact, adopted by the Local Government Board Committee in regard to heavy traction wagons (see paragraph 23 (*b*), page 14 of the Committee's Report).

Therefore the combined weight of a heavy motor car and trailer, *i.e.*, a tractor and trailer, should be limited only by the maximum legal axle weights.

Steam Wagons.—With regard to steam wagons, here again it is highly desirable that the designer should be allowed scope in the matter of weight, in order to remedy any defects that past experience has suggested to be desirable, ever keeping in mind the necessity for making the steam wagon as efficient and as dependable as the railway train.

The type of wagon that has proved itself to be the most robust and certainly the most popular in the past, is the wagon with a locomotive boiler with overtype engine. This machine has stood up to its work well and is largely used. As a consequence of its general efficiency, this type of wagon is being used and will undoubtedly be increasingly used for long-distance through traffic.

Such cases call for increased coal and water-carrying capacity, and therefore additional weight is desirable. Manufacturers, however, do not ask for excessive additions, and would be content if one extra ton could be added to the hind axle weight, raising it from 8 tons to 9 tons and making the total moving weight 13 tons instead of the present 12 tons. The addition of 1 ton to the total load, or 1 ton on the back axle, would not seriously affect the roads, and manufacturers believe that if this concession of 1 ton can be obtained, it would enable them to remedy certain weaknesses and thus guard against possible breakdowns, and also provide extra weight necessitated by the employment of larger water tanks and larger coal-carrying capacity.

In view of the extra weight of rubber tyres, it is also felt that when the wagon is so fitted, the total moving weight and also the back axle weight should be increased another ½ ton, making 13½ tons and 9½ tons respectively.

Manufacturers also feel that in regard to steam wagons the same definition of "unladen" weight should be adopted as suggested for the steam tractors, but with the "unladen" weight fixed at 6½ tons.

County surveyors have told the writer that there are conditions in which steel-tyred wagons can be more usefully employed than rubber-tyred wagons, and where this is the case the wagon with the steel wheel shod with cross-strakes is the wagon referred to. It must be admitted, therefore, that wagons thus fitted fulfil a useful purpose, and it is hoped that no attempt will be made to prohibit the use of cross-bars on such wheels, which are usually 3 ft. 6 in. in diameter, but that they may be allowed to be manufactured and used as hitherto.

Construction.—From the point of view of the construction of steam vehicles, there are two matters intimately associated with road maintenance.

First, the question of springing.

Second, the matter of the strakes on wheels.

The second of these has already been dealt with in the preceding section.

The question of springing is indeed a matter of paramount importance alike to the manufacturer, the road authority and the user.

All engines working under the Heavy Motor Car Order must be fitted with springs, but unless the springs are really efficient shocks will be imparted through the engine gears, with a rebound action on the road surface. Corrugations in the road surface, where they exist, will intensify such action with cumulative effect. Therefore the aim of the manufacturer must be to increase the efficiency of the spring arrangement, and thus help to reduce the wear and tear of the road, and it will be to the interest of all road authorities to encourage the use of the most efficient system available.

By way of illustration, and to show that manufacturers have not been indifferent to this important matter in the past, the writer may be allowed to state that from the early days he has taken a deep interest in this subject, and as far back as 1905 patented a system which had the effect of adding greatly to the range of spring movement.

More recently, however, he has taken a further considerable step in the direction of perfecting spring mounting for steam tractors, and would briefly describe his patent chain drive tractor with improved springing.

In this patent engine the springs are carried outside all gears, over the axle, and just inside the plane of the road wheels, thus providing the widest and flattest possible spring base. The springs are supported by a channel frame secured to the boiler and horn plates, and the whole arrangement allows of the use of long and flexible springs, which have a movement of 3 in. and are free to act as the springs on a carriage.

In order to provide this large spring movement, all gear for the final drive has been dispensed with, and a 2½-in. roller chain running on a sprocket wheel and pinion substituted. Thus two essentials are provided, viz., perfect flexibility and unlimited spring action. Durability is ensured by spreading the wear and tear over 35 teeth on the sprocket wheel and 5 teeth on the pinion.

This meant a completely new departure, as it had never before been done in the history of road engines. Chains had previously been used, but never combined with springs, and never adapted to engines constructed to work under the Light Locomotives Act.

This arrangement has been tested in actual use over a period of five years, and several are being used by county, district and borough councils, with complete satisfaction. It has been proved to ride perfectly steady and comfortably, so much so in fact that a driver has declared that he can work 2 hours longer daily on this patent chain drive engine than on any other.

It will be seen, therefore, that this engine offers the most ideal spring mounting at present available, and its general advantages are too obvious to need argument, viz.:—

Long flexible springs.
No limit to spring movement.
No rolling of the engine on a narrow spring base.
No shocks imparted through gears and transmitted to road surface.
Largely increased durability of the engine itself, and of the roads upon which it is used.

Speed.—It should be remembered that the speed of steam vehicles is by no means excessive. At present the 3-ton steam wagon on steel wheels is permitted a speed of 8 m.p.h., or, if fitted with rubber tyres 12 m.p.h., but a steam tractor with a trailer, or a 5-ton steam wagon on steel tyres, 5 m.p.h., or a rubber-tyred wagon 8 m.p.h. The Local Government Board Committee have recommended that where both tractor and trailer or steam wagon and trailer are mounted on rubber tyres, a legal speed of 8 m.p.h. may be allowed. Even at this increased speed steam vehicles will be slow when compared with other classes of machines, and it will be generally admitted that if all traffic were reduced to these speeds the roads would last considerably longer than is now the case.

Construction and Maintenance of Roads.—The writer has sometimes wondered if, in some cases, too great anxiety has been shown to strengthen the roads quickly by the use of enormous quantities of road metal, laid sometimes to a thickness of 4 in. to 6 in., raising thus the road level but not always improving the road surface.

The writer ventures to think that one cause of corrugations may be traced to the fact that the road metal is broken into many sizes and shapes, not accurately fitting together and not having the interstices filled up. This is laid upon a hard and more or less smooth surface, and then rolled to and fro', with the result that as the stones are free to rock on the hard base, the metal goes before the roller as waves, first in one direction and then in the reverse direction. In the course of rolling, some portions of the metal are ground off, but the road is never really solid; corrugations are formed, which quickly become worse by the wear and tear of traffic.

The writer believes that if road surfaces could first be well scarified and then laid with not more than one thickness of road metal, with granite chippings mixed with it to fill in the interstices as far as practicable before rolling, a more solid road with a smoother surface would result.

The value of steel-tyred traffic in making a good running surface should not be overlooked. The writer knows a piece of road over which steel-tyred traffic preponderates and there much smoother running is possible.

If smoother running could thus be secured it would result in greater economy in the upkeep of vehicles of all sorts, and less wear and tear on the road surfaces.

Weight, Construction and Speed of Heavy Motor Vehicles in Relation to the Construction and Maintenance of Roads.

By W. D. Williamson, M.I.A.E.

At its introduction, the self-propelled vehicle was allowed on the road on sufferance only, and this has been the position ever since. A manufacturer has been looked upon, in the past, by many road engineers as taking a fiendish delight in turning out a vehicle to have the utmost destructive effect on the road. This is very far from being the case, as it can be taken that, on a reasonably well constructed road, if the vehicle is destroying the road, the road is having an even more serious effect in destroying the vehicle, while on a bad road the vehicle suffers still more.

From the point of view of national interest, the preservation of vehicles is just as important as the preservation of roads, and it is just as necessary to pass regulations governing the strength and the nature of the surface of our roads as to pass regulations controlling the weight and speed of the vehicles using them.

The unfortunate position is that road makers are not direct profit earners. The commercial-vehicle manufacturer who builds a better vehicle obtains more orders, and other things being equal, achieves greater business success. The user who purchases the best vehicle, and who organises his transport arrangements to give the best service also builds up a successful business. In the case of the road engineers there is no such inducement. At present it might be argued that the reverse is the case. The better the roads, the more traffic is attracted over them, and the more wear they have to sustain.

On the present roads, which in many cases are just good enough to carry the traffic, high speed would undoubtedly be destructive to the road, and at the same time would be equally destructive to the mechanism of the vehicle. No motor manufacturer would suggest driving a vehicle over any road at a speed that would abnormally reduce the vehicle's life. Given suitable roads, however, the speed of heavy lorries would be very materially increased. The user of the lorry naturally wishes to make the most of its possibilities, and he is the man who is most immediately concerned in getting higher speed and increased efficiency from his vehicles. The manufacturer is interested in it from the fact that anything which increases the efficiency of the vehicle increases the uses to which the vehicle can be applied and, therefore, the demand for vehicles.

The statement that speeds are limited to ensure the safety of other users of the road will not bear investigation. A modern 5-ton petrol wagon is just as much under control in every way, at 20 miles an hour, as is a pleasure car, although its legally-permitted speed is only 8 m.p.h. A 3-ton motor vehicle has a legal speed of 12 miles an hour, yet a modern 5-ton vehicle, having good steering and good brakes, may be much safer at the same speed than an old type of 3-tonner which is permitted a speed 50 per cent. higher. That all legal speeds are ridiculously low from the point of view of safety, is shown by the fact that, during the railway strike, the King in hurrying back to London averaged slightly over 30 miles an hour for the 300 miles from Carlisle. We may take it that if this speed were really dangerous to other road users, it would not have been maintained.

The service capacity of the lorries we own in this country is reduced by between 25 per cent. and 50 per cent. due to restricted speed alone. The writer does not mean to infer that this is necessarily the case with our present roads, but given roads equal to our best roads, that would stand the traffic, there is no reason, either from the motor manufacturers' or the users' points of view, to prevent an increased speed, and consequently much more service from any given number of vehicles.

The legislation governing the use of heavy motor cars was made in 1904, and no credit has been given for the huge strides which have been made in design and construction since that date. The points about which we are most concerned are that we are not permitted to have an axle weight of more than 8 tons, that a vehicle with an axle weight of 8 tons can only proceed at 8 miles an hour, and with an axle weight of 6 tons at only 12 miles an hour even when shod with solid rubber tyres.

In the case of heavy motor traffic damage is principally attributed among other things, to the unladen weight of the vehicle and the uneven distribution of the weight over the axles, the use of wheels of small diameter, the propulsive effort of the vehicle, the action of solid rubber tyres as they expand and contract when coming into contact with, and leaving, the road surface, the hardness of solid rubber tyres when worn, the impact and the speed, more especially when there are any gradients in the surface, or pot holes due to lack of repair.

In the report of 1918 there is no evidence to show that the road authorities generally consider that the maximum weight of 12 tons for the total laden weight of the heavy motor car, 8 tons for any axle of the car and 4 tons for any axle of the trailer, are too high for good class roads. In fact, one or two surveyors are disposed to allow some slight increase.

Even from strict considerations of road damage it does not appear necessary to limit the axle weight of a trailer to half that of the vehicle which produces the tractive effort. It appears curious also to continue the limitations of unladen weight. The control of axle weight and gross weight should be quite sufficient, as the interests of both manufacturer and user are to have a small tare compared with the gross and the limitation of unladen weight appears to be unnecessary.

Comparing the vehicles of different countries we find reflected in their design and construction, the national characteristics of the race, and the influence of the roads.

The solid reliability of British design is characteristic of all our engineering work. British roads do not tend to produce vehicles which can be used at high speeds, as there are very few stretches of road without curves or corners, and with the exception of stretches on some main roads, the surface prevents any attempt at high speed. This has tended to the production of a vehicle where springing has received great attention, not only

in the road springs of the chassis, but in the upholstering of the body.

Colonial conditions again call for special treatment, and here the influence of the roads, or lack of roads, on the design is seen immediately. High ground clearance, large wheels and increased engine power are required. Increased cooling capacity is also necessary, partly due to climatic conditions and partly to the necessity of running for long periods on low gear over bad or soft roads.

In France and Belgium, during the war, many vehicles which had been perfectly satisfactory at home on normally good roads, and very successful indeed on roads such as are found about London, had their weight capacity reduced when they were put on to the rough roads of the war area. The *pavé* roads of Belgium, on account of their solid foundations, undoubtedly saved the situation, but their vile surface reduced the carrying capacity of transport vehicles passing over them, and at the same time increased the cost of repair of these vehicles. The attitude of some motor manufacturers is a proof of their appreciation of this position inasmuch as they would be quite prepared to guarantee the same vehicle to carry heavier loads in the London area than they would, say, in Lancashire or Yorkshire.

The road with broken or uneven surface is the road which in this country has the greatest influence on design.

In a short trip of 20 miles one may encounter good setts, bad setts, good tar macadam surface, wood paving and rough macadam. The chassis designer is faced with the problem of producing a vehicle which will give good results on any of these surfaces. To consider the matter of petrol-driven commercial vehicles only, it has already been shown that the roads have an influence on the carrying capacity. To pursue this subject further it would be safe to say that given roads with really good surfaces vehicles would be produced which would impose upon the roads less total weight for the useful loads carried. These lighter vehicles would have less ill effect upon the roads than present vehicles have, and would consequently reduce the upkeep of the roads.

It is obvious that, under existing conditions, except for special vehicles which are to be used in a known area, the motor manufacturer must provide vehicles fit to carry loads over the worst roads. This means additional strength, and as a result, additional weight.

The road wheels must be of robust design to withstand the shocks, and the front and rear axles must be stronger and heavier than would be required for universally even roads.

These parts are entirely unsprung and we are told that unsprung weight is largely responsible for damage to roads. No doubt, on a road which already has an uneven surface, the question of unsprung weight is serious. Given, however, a good surface on a solid foundation it is perhaps of less importance. It ought not to be necessary, when considering the effect of the vehicle on the road, or of the road on the vehicle, to assume that pot-holes must be present.

The steering gear is another portion of the chassis which has to be designed with special regard to the shocks which may be received as the direct result of striking uneven road surfaces, and as the result of vibration through passing over rough roads. A portion of the weight of the steering gear is also unsprung, and can almost be taken as part of the front axle weight.

In the case of the springs, it is necessary to provide for varying loads and for varying road surfaces. They must, in addition, be suitable to deal with rolling which arises largely from excessive camber and from sudden deviations from the straight. There is no doubt that spring systems could be substantially improved with great reduction in weight if road surfaces were better.

The main frame of the chassis has also to be given additional strength on account of road shocks, and so we could proceed through almost the whole of the mechanism.

The provision of smoother and more suitable road surfaces would also help very largely in the way of decreasing the cost of upkeep and of operation. The upkeep of commercial vehicles varies very considerably in different parts of the country, due to the state of the roads.

When considering the running cost of tyres, it should be pointed out that the interests of the road maker and the road user are here identical. One cannot have tyre wear without road wear. The interests of the user are naturally to obtain the longest possible life from his tyres, and the interest of the road maker to obtain the longest life from his road. The designer and manufacturer of the vehicle, in thinking in terms of total cost of operation, must take the question of tyre wear into account, and incidentally, therefore, road wear.

Tyre wear is caused very largely by wheel spin on rough road surfaces. When the wheel rises from the road, after striking an obstacle, its speed of rotation immediately increases, and by the time it hits the ground again the surface of the tyre is travelling at a speed too high for the speed of the lorry. This is one great cause of tyre abrasion, and must equally cause road wear. The effect of the roads on tyres is well illustrated by the mileage obtained from tyres used on 'buses in the London streets, compared with mileage that could be obtained on vehicles in Lancashire. In pre-war days 15,000 miles to 20,000 miles could be obtained from a set of tyres in London, whilst on the rough roads of Lancashire tyres in many cases failed to give the guaranteed mileage of 10,000.

Practically all petrol-driven commercial vehicles used in this country having a carrying capacity of over 1 ton are shod with solid rubber tyres, but this is not by any means the last stage of development. Trials are being made, both in France and in America, of pneumatic tyres for heavy vehicle use, and improved road surface would undoubtedly hasten the advent of this very desirable development.

Monsieur André Michelin has conducted a large number of experiments, during the last two and a half years, in the use of multiple pneumatic tyres for heavy vehicles. The result of the tests, as far as the tyres alone are concerned, has been very satisfactory. The chief difficulty appears to be of a mechanical nature, connected with the production of a satisfactory detachable rim, to allow for the handling of large-size pneumatic tyres.

To examine in detail the effect of the roads on the running cost of a vehicle the following figures are put forward, not necessarily as being strictly accurate, since costs must vary from district to district, but as being approximate for average conditions. The vehicle under consideration is one for useful loads of 4 tons, the vehicle itself weighing 4 tons, making a gross weight of 8 tons distributed as to 2 tons on the front axle and 6 tons on the rear.

Present legal speed of vehicle, 12 m.p.h.
Cost of vehicle, about 1,200*l.*
Tyres, per set, about 60*l.*
Weekly mileage, 300 for 50 weeks a year.
Interest is charged on the total price of the vehicle.
Depreciation is charged on the total cost less the cost of tyres, which are accounted for as a separate item.
Petrol consumption, 7 miles per gallon.

Running Cost of 4-Tonner at Present.

	Yearly Cost. £
Interest at 5 per cent.	60
Depreciation at 15 per cent.	170
Driver's wages, 65*s.* per week	169
Insurance	15
Petrol at 2*s.* 8*d.* per gallon	286
Oil and grease	25
Tyres (life, 10,000 miles)	90
Repairs	100
Total yearly cost	915
	d.
Cost per mile	14·64
Useful load cost per ton-mile	3·66

If roads were uniformly good the useful load could be increased by at least half a ton for the same gross weight of vehicle. The speed of the vehicle might quite safely be increased to 16 m.p.h. The tyre life could at a very low estimate be taken at 50 per cent. more. Taking the average tractive resistance of our present roads at 60 lb. per ton, and of the good road at 30 lb. per ton, in spite of the extra speed we should have a reduced petrol consumption, and this is taken at 9 miles per gallon. The repair bill would certainly not be more, and depreciation would be materially less.

The running cost would then be as follows, taking a yearly mileage of 18,000.

	Yearly Cost. £ *s.*
Interest at 5 per cent.	60 0
Depreciation at 12½ per cent.	142 10
Driver's wages	169 0
Insurance	15 0
Petrol at 2*s.* 8*d.* per gallon	267 0
Oil and grease	30 0
Tyres (life, 15,000 miles)	72 0
Repairs	100 0
Total yearly cost	855 10
	d.
Cost per mile	11·4
Useful load cost per ton-mile	2·53

This shows a saving of over 30 per cent. on our total haulage costs, and is a result worth more than mere monetary consideration.

The present 5-ton vehicles would safely carry an additional ton of useful load on really good roads, and the legal speed, instead of 8 m.p.h., could be at least 12 m.p.h. This would show an even greater percentage of saving than the 4-tonner.

To conform with the present maximum axle weight of 8 tons for heavy vehicles, the ordinary petrol lorry can carry little more than 6 tons. An increase in the permitted axle weight, in conjunction with suitable roads, would reduce the cost of transport enormously. The cost per ton-mile of useful load decreases with an increase in the load.

In addition to making allowances for the actual surface, the automobile engineer has to design a vehicle to negotiate deviations from the straight line in both horizontal and vertical directions. In order to be able to steer a long vehicle round a short radius the wheel base must be reduced with the effect, as seen in many char-a-bancs, of having excessive overhang. These sharp corners also make for rolling and are the cause of additional tyre wear.

Deviations from the straight line in a vertical direction are generally the result of the physical characteristics of the district through which the road is made, but careful engineering can lay a road having reasonable gradients through the most unpromising country.

If we compare the gradients on a well-laid road with those of the railway we see how far from ideal is the road. In order to be able to climb gradients on the present roads vehicles have to be fitted with engines considerably bigger than would otherwise be necessary. This means, that practically the whole time the engine is working at about half full load, and consequently is not working economically.

There are also smaller artificial rises, such as one finds on secondary roads, in particular over small bridges which, if crossed at a high speed may be the cause of serious damage. A sudden change of gradient, as on a humpy bridge, means the necessity for high clearance amidships of a car or lorry.

Considerations of gradient and road surface play a very important part in the question of weight distribution. Take as an instance the case of a vehicle which, in its daily work, has to climb a hill having a soft and slimy surface; instead of the co-efficiency of friction between the wheel and the road being in the neighbourhood of 0·4 it may diminish to 0·2, and yet the tractive resistance of such a surface might be 100 lb. per ton. Taking the vehicle as weighing 8 tons gross, and the gradient as 10 per cent., we have:—

	Lb.
Tractive resistance due to gradient	1,792
Tractive resistance due to surface	800
Total tractive resistance	2,592

This means 2,592 ÷ 2 = 12,960 lb. weight on driving wheels to give the required grip.

Therefore, at least 5½ tons of the total weight of the vehicle must be on the driving wheels to meet these conditions, whereas with a coefficient of friction of 0·4 half this weight would have been enough. The retarding power of the brakes is subject to the same influence.

Driving on all four wheels has received consideration, and, in fact, vehicles of this type are built, but it means additional mechanical complication, and increased cost of manufacture. As a vehicle for special conditions, the four-wheel drive wagon has a field of its own, but it should not be necessary on normal roads. The provision of roads having uniform surfaces would enable renewed consideration to be given to this very important question of weight distribution.

The war has taught many things to the builder of heavy vehicles. The condition of the roads overseas, whilst not introducing any new features, certainly did exaggerate the conditions to such an extent that troubles which are so small under home conditions as to be negligible, played a very important part in the difficulties which had to be contended with overseas. Whilst it would perhaps not be advisable to re-design to suit these exaggerated conditions, they did prove that motor vehicles are depreciated, to some extent, from causes which would not appear at first consideration to be of any great moment. As an example of this, roads having a soft upper surface were extremely dusty in the dry weather, and with vehicles working in convoy this dust had a serious effect upon the running of the vehicles. It was taken into the cylinders, and, mixing with the lubricating oil, made an ideal grinding compound, which quickly caused excessive piston wear, with all the usual troubles that follow. A filter for the intake air to the engine was suggested to overcome this trouble. This same evil must be occurring to a limited extent on our own roads. In addition, the dust penetrated to all the mechanism, and tended to shorten the life of the vehicles.

In wet weather the same roads were almost impossible to negotiate, and the vehicles had to be driven under reduced load. Lorries side-slipped into ditches and into each other, the results being costly to the country in every way. The liquid mud, even more than the dust, penetrated to all parts of the vehicle, and had a most destructive effect on steering connections, brake connections, joints and wearing parts of all kinds.

Mention might also be made of the fact of running vehicles on sand in Egypt, where the sand penetrated to the interior of crank-cases, gear-boxes, and back axles, and of the expedient which had to be resorted to of laying down wire netting to form tracks for the vehicles. These conditions, however, are somewhat outside the scope of the present paper.

Much has been heard as to the advisability of providing larger road wheels, and here again we can take it that the standpoint has been the present condition of the roads. The large wheel is undoubtedly better for rough roads, it does less damage to the road and causes less damage to the vehicle itself. It is not proved, however, that with roads in good condition there is any advantage in having wheels of more than moderate size. The motor manufacturer has no interest in providing small wheels, what he wishes to do is to provide wheels that will give the best possible results in every direction. With regard to diameter he is limited, to a very great extent, by the requirements of the user of the vehicle. The height of the road wheel governs the height of the loading platform, and with wheels too large in diameter the platform is higher than is convenient for loading by hand from the ground. In the case of the subsidy-type vehicles, as specified by the Government, wheels are about 41 in. diameter over the tyres, necessitating a platform level of over 4 ft. For loading into and out of railway trucks, or special wharves, there is no disadvantage in this, but many prospective users of the vehicles find that for loading by hand from the ground this level is too high, and naturally refuse vehicles with wheels of this size. A motor manufacturer, therefore, is forced by the requirements of his clients to fit wheels which will permit a platform of reasonable height.

It must also be remembered that an increase in wheel diameter means more than a proportionate increase in weight. In the case of live-axle type vehicles it also means heavier driving mechanism, and a heavier axle to contain it. All this is unsprung weight.

Road engineers must be prepared for a very large increase in the number of goods-carrying vehicles in use on the road. Before the war, very many possible users of commercial vehicles were not convinced that they offered a reliable or economical, means of transport and did not adopt them. They had not, in fact, been educated

to their use. Every man who was overseas during the war came back having had the motor lorry as part of his daily scheme, and perfectly convinced of his powers to carry on even under conditions very much worse than are likely to obtain in this country.

The recent railway strike has had the effect of convincing many heads of business houses that for moderate distances the motor lorry offers a quicker, cheaper and more convenient means of transport than the railway, very largely on account of the terminal charges of the railway, which are the same, for short distances as for long ones, of terminal delays, and of the carting to or from the railway yard at each end of the journey. The result is that during the next few years the roads will be more used, and it is for the road engineer to provide roads which will carry the traffic, and carry it a a reasonable speed.

The increasing volume of heavy motor traffic will be still further augmented if the railways, in order to be put upon a strictly business basis, are forced to raise their goods rates. Even at the present time carrying companies collect and deliver goods more quickly than can be done by the railways, and at a price which is competitive with present railway charges, although the railway is subsidised, whilst the carrying companies are run by private enterprise. In the event of the railway companies having to raise their rates the balance would be all in favour of road transport, and road authorities must appreciate the position that during the next few years our roads will be carrying very many times their present weight of traffic.

The recent railway strike taught us another lesson. It taught us that with our present facilities, road transport cannot take the place of the railways. Although possibly the vehicles are equal to it, the roads most certainly are not. I have it on the authority of one of our most eminent road engineers that our present roads are totally unfitted, from their narrowness and surface, to deal with a national emergency of this description for any length of time. When we consider that this carefully considered statement is based on results obtained when practically only the essentials of existence were being carried, we can judge as to the effect if the requirements of industry had to be road borne as well. It is perhaps inadvisable to say more on this subject, but it should be one of the first considerations of the Ministry of Transport.

The road of the future should be constructed entirely from considerations of its suitability for self-propelled vehicles. In the future the horse-drawn vehicle will as rarely be seen as is the bullock wagon.

The first great necessity is a series of wide trunk roads constructed specially for motor traffic. Roads with good foundations and waterproof surfaces which will not wear into pot-holes. These main trunk roads should not, as a general rule, pass through large towns, but should pass on the outskirts, and be linked up with the towns by equally good, but not necessarily such wide roads. The through traffic would not then have the effect of further congesting local traffic, and the local traffic would not retard fast through traffic. In the event of works, warehouses or other business premises being built near these roads, care should be taken that the free passage of moving vehicles is not prevented by vehicles delivering or receiving goods.

The automobile engineer would like to see all roads on much more substantial foundations than are usually used, in order to carry greater weights at higher speeds, and having an upper wearing surface of a dustless character which can be easily renewed. It ought not to be impossible to build such roads and allow on them an axle weight of, say, 10 tons with a gross weight of 15 tons and a speed of 16 m.p.h., for vehicles fitted with rubber tyres of agreed dimensions, even if the increased speed is not at once permitted on existing roads of a less substantial character. Further, when any vehicle is using the roads strictly in accordance with the regulations, it should not be possible for the vehicle to do "extraordinary damage."

Corners should be eased and blind corners entirely eliminated. At all corners the road should be given super-elevation. This is already being successfully done by some engineers. The super-elevation eases the vehicle round the corner, prevents tyre slip, and consequently prevents wear on both tyres and road. The foundations of the road appear to be much more important than the top surface. It ought not to be permissible to put pipes, drains, electric cables or anything else beneath the roadway which may make it necessary to excavate. The foundations of a road should be solid and permanent.

To prevent accidents reasonably open spaces to cross roads are required. Reconsideration of the camber of roads is necessary, roads with a dressed surface such as tar macadam roads, which are waterproof from their construction, do not require the camber often found in roads to-day. The road surface should be of such a nature as to have low resistance to rolling, while the coefficiency of friction between the road and the wheel should be high.

The present methods of indicating direction in many cases leave much to be desired, improvements could be made at very little cost.

"Daily Mail" Efficiency Exhibition.—We are informed that *The Daily Mail* proposes to hold at Olympia, in February, 1921, an Efficiency Exhibition, the purpose of which will be to bring under one roof every conceivable method, system and machine which can save time, labour and effort. The exhibition will cover every phase whatsoever of human activity and must therefore be instructive.

SINGLE AND DOUBLE-COAT BITUMINOUS ROADS.

*The Relative Advantages of Single and Double-Coat Road Surfacing Work carried out in Bitumen (as Distinct from Tar Compounds).**

By Francis Wood, M.Inst.C.E., Borough Engineer and Surveyor, Blackpool.

Motor traction has made such progress during the war that it has now become fairly well recognised as a serious competitor of railways for transport purposes, more especially for short-distance traffic, *i.e.*, up to a radius of about 40 miles. The motor car is becoming even more popular, and it is a fair assumption that roads will, in the near future, have to submit to traffic which is far beyond present or past limits. Roads which in the past have been subjected to light traffic will also, in all probability, be subjected to heavy traffic, and the structure of the road must therefore be considered as having to submit to this class of traffic.

It will be found to be equally as cheap and as economical to provide a satisfactory road structure for secondary roads as it is for the main roads.

There are many who regard the first cost of the road structure as the determining factor. In the writer's opinion this is far from being a satisfactory view. The cost of a road is certainly an item that should receive careful consideration. It is far preferable fully to exploit all the possibilities of the structure that is the most satisfactory, viz., to see whether loans cannot be extended over a greater period more in conformity with the actual life of the structure: to see whether it is not possible to obtain the material at a cheaper rate by purchase in a more direct manner, &c., &c.

Some years ago, whenever a macadam road in the district under the control of the writer cost about 1*s.* per superficial yard per annum, it became a rule that that road should be wood paved, because during the period of the life of such a pavement, the cost would be lower than 1*s.* per superficial yard per annum. Twelve miles of wood-paved roads in Fulham cost about 6*d.* per superficial yard per annum, and the heaviest trafficked part of the Fulham-road cost about 9*d.* per superficial yard per annum. Since then, bituminous structures have been found to be much cheaper in first cost and to have a life of at least fifteen years, thus a modification was made to the rule, so that wherever a macadam road was costing more than 4*d.* per superficial yard per annum, this form of structure was substituted; it gave not only a better surface requiring less attention and a far longer life, but it was over its life not more costly to maintain.

An examination of main road statistics indicate that there are nearly 5,000 miles of main roads, which on the average cost about 5*d.* per superficial yard to maintain, and by the substitution of a new bituminous structure there would be, in the writer's view, a saving in the cost of maintenance, apart from betterment, in other directions.

The bituminous structure that has been mentioned is one that is known as the two-course pavement, *i.e.*, a base coat and a wearing surface coat. The base coat has been simplified and made as cheap as possible by using broken hard stone, of any kind, from granite, clinker, York stone, limestone, bricks, &c., or from the old material scarified out of the road itself, the size being from 2 in. to dust, 60 per cent. of the mixture being of the larger material. It is mixed with a composition of tar, pitch and bitumen, which gives a penetration of 120 at 60 deg. F. on a Bowen penetrometer. The material is heated to about 400 deg. F. and the previously-mentioned bituminous mixture is added when the material is under 300 deg. F., thoroughly mixed in a mechanical mixer and taken to the prepared road, and laid whilst still hot to a depth of 3 in. This base coat, as soon as it is cold, is so tenacious that a lorry with a load of 10 tons can come on to it and make but the slightest impression of its track. The surface of this base coat has an open appearance, such as will give a good key for the material that is to be laid on the resulting surface as a wearing coat.

This wearing surface coat is composed of a graded aggregate of mineral particles such as sand, granite dust, cement and bitumen, the grading being: 40 per cent. passing through 200, 100 and 80 meshes (one-third passing the 200 mesh), 40 per cent. passing through 50 and 30, and 20 per cent. being of the 20 and 10 mesh and bitumen—the latter is about 12 per cent.

A few years ago the writer was impressed with the idea that a single-course pavement would prove to be one that would give satisfaction, and a number of experiments were made which seemed to amply justify that conclusion, with the result that several miles of roads were laid, the composition being almost precisely the same as is found in an ordinary macadam road, but bitumen was used as a substitute for moisture. The whole of the material was mixed, as described above, in a mixer, so that the bitumen (about 8 per cent. by weight) entirely covered the stone and other particles. After about the fourth or fifth year, under heavy traffic, the structure gave signs of surface disintegration. The writer's impression of the causes is, that the bitumen expands and contracts under atmospheric temperatures to an extent which is unequal where large stone is in the surface and must come in places to the surface but extending downwards to a depth of 1½ in. to 2 in.; that there is, therefore, a liability to leave infinitesimal fissures into which moisture, such as dew, &c., enters and prevents readhesion; this would, in the end, be sufficient to cause the effect mentioned. He came to the conclusion that, where a material is to be laid and which is to act as a wearing surface, the aggregate in the composition should in no case be larger than ¼ in. Such a composition would not necessarily be stable under heavy loads, and it therefore becomes necessary to divide it into two parts or coatings, the lower or base coat to act as a support and foundation for the upper or wearing surface coat, which is composed entirely of small-sized particles and bitumen. This method has proved very satisfactory and as cheap as the single-coat structure.

A coating of tar, on the finished surface of a tar-macadam road, is invariably necessary to complete its effectiveness. Unfortunately, such a coating of tar scarcely lasts beyond twelve months, and if this coating is not repeated, the wear or deterioration is rapid. If the cost of this annual coating is capitalised, and the resulting amount expended on a wearing surface coat about an inch in depth, the tar painting, which is an annual annoyance to traffic is dispensed with, and a better and more lasting surface is gained.

The writer has made for light trafficked roads a one-course pavement which may be said to be intermediate between compressed or artificially-made asphalt and mastic asphalt, *i.e.*, it is not so rich in bitumen as the latter but more so than the former; it can be laid more quickly and effectively as compared with mastic asphalt; and it satisfies medium trafficked roads where the expense of a two-course pavement may be a serious item.

Assuming the mixture of tar, &c., for the base to cost 1*s.* per gallon, and that 10 gallons is used per ton of material, then the cost of the mixture is 10*s.*, to which labour costs 4*s.* 6*d.* per ton, making the total cost of the base 14*s.* 6*d.* per ton; add 3*s.* 3*d.* per ton carting each way, the cost on the job is 21*s.*, at 7 yards per ton equals 3*s.* per superficial yard. The surface wearing coat is about 90*s.* per ton at present prices, which are exceedingly high, and it is hoped will soon come to a more reasonable figure. This equals 4*s.* 6*d.* per superficial yard. Allowing 2*s.* 6*d.* per superficial yard preparing the surface, &c., the total cost is 10*s.* per superficial yard.

* Abstract of a paper read before the County Councils Association Road and Transport Congress, on November 24, 1919.

Swedish Trade Mark.—We read in *Swedish Export* that in the course of the preparations made in various lines of business to equip Swedish export industry for the severe competition anticipated in connection with the restoration of peace, great hopes had been attached in many quarters to the project of a national Swedish trade mark. The body which took up and followed out the suggestion was the General Export Association of Sweden, which subjected the question to a careful investigation—amongst other methods by sending out a circular of questions to the industries and exporters of the country. The result of this inquiry, at least for the present, has been negative, it being found that under present circumstances such a trade mark would bring Swedish exports more disadvantages than advantages.

Large Fuel Deposits in Estland.—Estland appears to be better off for fuel than most of her neighbours thanks to her vast deposits of a kind of shale, which has proved a very useful fuel. The deposits in question extend from the coast as far as Wegenberg, over an area 80 versts long and 10 versts wide. The amount of these deposits is estimated by experts at 1,500,000 000 tons. Analyses have shown that the substance contains a large percentage of oil, so much so, that if one puts a lighted match to a piece of it, it will burn. This fuel is used for the production of gas and electricity in Reval, and it is also used as fuel in numerous factories and private houses. A number of locomotives are being altered so as to be suitable for this fuel in place of wood, which is now used. In the pulverised state it is being used for fuel under boilers and gives general satisfaction, although it certainly produces a large amount of ash. This drawback can, however, be counteracted by suitable construction of the furnace. Its calorific value is between 50 per cent. and 60 per cent. of that of coal, but this is more than compensated for by the fact that it costs, at present, only about one-fourth as much. The deposits are already being worked in different places by the Estnian State and much importance is attached to the national exploitation of the deposits; the matter is also understood to have attracted some attention in England.

Shortage of Water in Sweden.—Owing to the small rainfall in many parts of Sweden during the autumn, some of the large hydro-electric power-stations are in difficulties owing to the limited flow of water in the rivers. This applies to the Dalar River, for instance, and the new Stockholm Municipal Power Station, the Untra Station, although not yet being worked to its full capacity, has been obliged to reduce its output of electric energy. This necessitates an increased working of the reserve steam power station in Stockholm. The State power station at Alfkarlebz was only receiving 180 cub. metres of water per second instead of 400 cub. metres per second dur ng last year. The power station, however, has a clause in its agreements, that, when the volume of water falls below 225 cub. metres per second, the station is either relieved from its obligations to supply energy or the price is raised: this clause does not apply to current for agricultural purposes. Consequently the steam power station at Västeras is being rather heavily loaded, the present load amounting to about 100,000 k.w.h. per 24 hours. Neither the Trollhättan nor the Porjus State power stations have so far been inconvenienced from water shortage. The Gäfle municipal plant, on the other hand, is only able to generate half the energy it did last year. Water is also very low in Westmanland in the Motala River and in Enaen. In all these districts the power supply has to be maintained by steam plants.